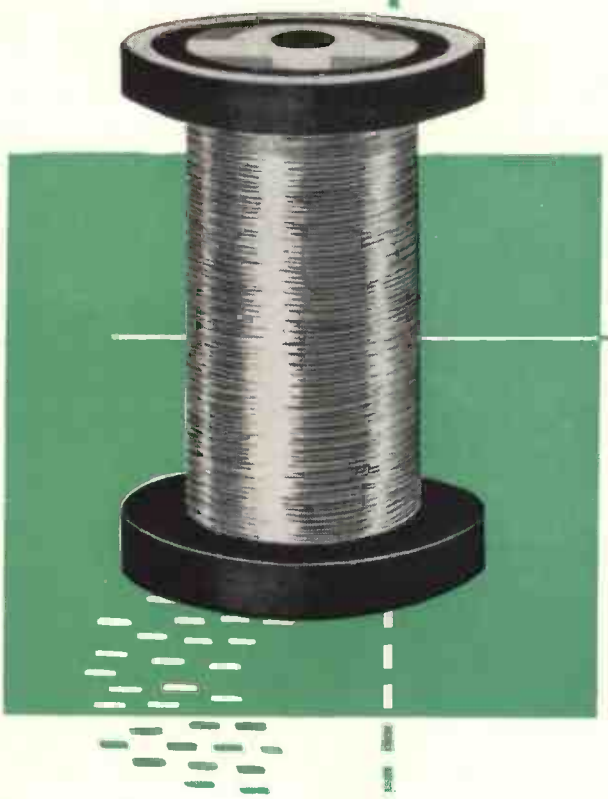
MARCH 1957 TWO SHILLINGS

Wireless World

ELECTRONICS

Radio · Television

FORTY-SIXTH YEAR OF PUBLICATION



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Wireless World

ELECTRONICS, RADIO, TELEVISION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
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MARCH 1957

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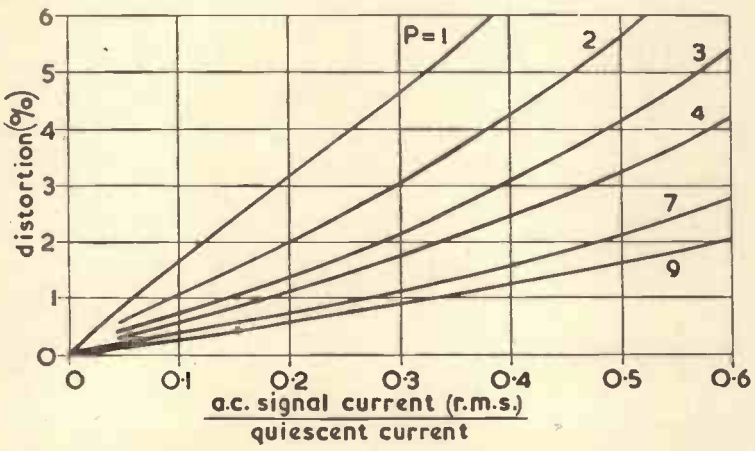
Distortion in Transistor Amplifiers

In high quality amplifiers, low distortion is essential. Hence a knowledge of the causes of distortion in transistor amplifiers, the means of estimating distortion and reducing it should prove extremely useful. The following account includes a brief analysis of distortion in low level transistor stages and a graph from which distortion in OC70 and OC71 stages can be obtained.

Causes of Distortion

In a transistor amplifier operated with grounded emitter, distortion results from two causes. First, for a sinusoidal voltage input the input current is non-sinusoidal because of the intrinsic non-linearity of the voltage-current characteristic of the emitter junction. This is the input circuit distortion. Second, for a sinusoidal current input to the base, the collector current is non-sinusoidal due to variation of the collector-to-base current gain (β) with the collector current. The distortion due to the latter is normally small and can usually be neglected.



Input Circuit Distortion

The input characteristic consists of two parts: that of the base-emitter junction itself and that of the part of the base between the junction and the soldered connection. The voltage-current relationship of the semiconductor junction is exponential: $i \propto e^{v}$.

The effective incremental resistance of the junction r_{exp} at the working point, as seen from the base is given by the formula

$$r_{exp} = \frac{25}{I_e}\beta \text{ ohms},$$

where I_e is in milliamps.

The base resistance $r_{bb'}$ is however nearly ohmic and approximately equal to 450Ω in the OC70 and OC71 for values of I_e between 0.5 and 5mA. The main component of distortion produced by the non-linearity of the junction characteristic is second harmonic (D_2) and only this is considered.

It can be shown that distortion is proportional to the ratio of the r.m.s. signal current to quiescent current, and inversely proportional to 1 + ratio of total ohmic resistance to r_{exp}. i.e.

$$D_2 \propto \frac{i_{e\,(r.m.s.)}}{I_e} \text{ and } \frac{1}{D_2} \propto 1 + \frac{R_b + r_{bb'}}{r_{exp}}$$

where R_b is the external input circuit resistance. These two relations give the variation of distortion with circuit and operating conditions. The accompanying graph shows actual values of distortion plotted against the ratio of r.m.s. emitter signal current to quiescent emitter current at I_e = 2mA for several values of a parameter P which is the ratio of total ohmic resistance to exponential resistance in the input circuit.

$$P = \frac{R_b + 450}{r_{exp}} = \frac{(R_b + 450)\,I_e}{25.\beta}$$

The graph may be applied without serious inaccuracy to OC70 and OC71 stages operating at I_e = 0.5 to 5mA and the input circuit distortion can therefore be derived from it for all likely practical amplifiers.

Distortion due to Current Gain Variation

The collector-to-base current gain varies with the collector current (I_c), but this variation is small over the operating range; the gain reaching a maximum at about 1.5mA for an OC71.

When the operating point is at the current for maximum gain, distortion due to β variation will be negligible. Provided that I_c is kept above 0.2mA the effect of β non-linearity is small and may add to or subtract from the input circuit distortion, depending on whether I_c is less than or greater than the value giving maximum β. The amount of distortion can be estimated from the transfer characteristic by conventional methods. Thus the accompanying table gives the amount of second harmonic distortion corresponding to the ratio of the amplitude of the two half-cycles of the output waveform.

Ratio	1.01	1.02	1.04	1.08	1.16
D_2%	0.25	0.5	1	2	4

Emitter Feedback

When an external series emitter resistance R_e is used to linearise the characteristic, its effect is equivalent to the addition of an external base resistance of value $R_e\beta$. Thus the graph can still be applied provided that the value of P is calculated from the formula

$$P = \frac{R_b + \beta R_e + 450}{r_{exp}}$$

Emitter feedback also reduces the distortion due to variation in current gain.

Mullard T.S.O. DATA and PUBLICATIONS SECTION, MULLARD LTD., MULLARD HOUSE, TORRINGTON PLACE, LONDON, W.C.1
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EDITORIAL COMMENT

Wireless World

MARCH
1957

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COLOUR TELEVISION PITFALLS

There is a risk that the demonstrations of colour television given recently to Members of Parliament may have been too successful. Quality of the transmission was so good that it might well have provoked the light-hearted and over-optimistic decision that we need look no farther before adopting the British version of the American N.T.S.C. system for our national service.

According to a growing weight of informed opinion, that would be a premature and probably disastrous decision. Nobody denies that the N.T.S.C. system is ingenious and elegant or that the British adaptation of it preserves all the good points of the original. But American experience alone gives the warning signal for extreme caution. In almost every respect colour television in the United States has so far been a failure; the receivers have proved to be too expensive, to require too much maintenance and to be too difficult to adjust. There is no reason to believe that adoption here of the Anglo-N.T.S.C. system in its present form would have a significantly different outcome.

One of the shortcomings of the N.T.S.C. system is that it was planned basically for use with an inherently expensive and complex display device—the three-gun shadow-mask tube. What is still lacking is a cheap and simple display device, which surely must be necessary for an economically practicable colour service. Dr. E. L. C. White, writing in the February *Wireless World,* developed the argument for evolving a system not tied to the three-gun tube.

The question of compatibility inevitably arises. The general belief is that a colour service would be economically impossible in the near future unless it were receivable on existing black-and-white receivers. That is probably true; but, if there is any validity in what we have just said, it is equally true that, as no economically practicable system offers itself at present, there is no prospect whatever of starting a regular service during the next three or four years. If that be so, the question of compatibility becomes of lesser importance. In five years' time, say, the revenue from licence fees may be expected to have reached a figure large enough to support a parallel colour service without any need for compatibility.

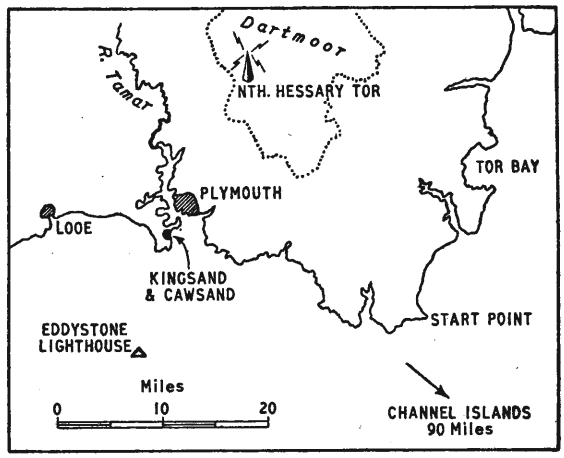
VALVES IN THE LIMELIGHT

Everyone knows—though usually in quite a vague way—that valves are sold in rather a peculiar manner. Sales to manufacturers of broadcast receivers and other equipment are at prices which are disproportionately low in relation to the retail price. The report of the Monopolies Commission, referred to on another page, shows the position to be a good deal more complicated than that. The valve is at the heart of our affairs, and probably nothing but good will come from bringing these matters into the limelight. It has been argued that the policy has been justified by results and that it has helped to keep the prices of all equipment at a low level: further, that the cost of maintaining stocks of replacement valves justifies their price. It is to be hoped that these matters will now be freely debated by all sections of the industry.

Television Interference Problem

BEAT EFFECT ON RECEPTION FROM NORTH HESSARY TOR

By JAMES P. GRANT, Assoc.Brit.I.R.E.



Map showing the district in which the interfering beat effect is experienced.

WHEN the North Hessary Tor television station came into operation in Channel 2 in December, 1954, reception from the temporary transmitter and 150-ft mast was reasonable in the Plymouth area. However, at Kingsand and Cawsand on the Cornish side of the River Tamar, close under a 450-ft hill which screens the two villages from the transmitter, reception was generally poor. Four-element aerials were necessary, and even then reception was marred by a constant pulsing effect. This took the form of a beat with a repetition frequency of around 40 a minute, giving fluctuating brightness and line pulling.

This effect was generally considered to be a symptom of the low power, low transmitting mast and high intervening hill. Viewing was possible and the inconvenience was endured for 14 months in the belief that the permanent station and high mast would cure the trouble. There was some dismay, therefore, in February, 1956, when the permanent transmitter came into service with the temporary 150-ft mast. The pulsing effect was certainly no better—if anything a little worse. Moreover, when in May, 1956, the main transmitter started to radiate from the high mast, the pulsation was so increased as to make viewing virtually impossible at times.

Rotating radar beacons have been eliminated by practical experiment, and tests indicate a reflection of the Hessary Tor transmission by some unknown object seawards which combines with the direct wave to form a fluctuating signal with a frequency of between 35 and 50 a minute. The reflection is not sufficiently well defined to show a definite ghost, but it has been estimated to be as much as 7% of the main 300-μV signal. The amplitude and speed of the beat vary from hour to hour, from day to day, and between daylight and darkness.

The effect is always present when Hessary Tor is transmitting, but is more severe on high power than during breakdowns and test periods on reduced power. It can be observed only on sites shielded from Hessary Tor by high ground open to the sea and within the limits of Start Point and Looe. It is fairly certain that the beat is present at all sites within this area, but is observable only when the shielding of the direct signal renders the reflection a significant part of the whole received signal. The maximum effect is at Cawsand at about the centre of the affected area, and the intensity of the beat reduces progressively towards the outer limits.

There is no recorded signal throughout the band when Hessary Tor is not transmitting. During severe beating there are ghosts, which successively reduce in intensity and appear to continue to the end of the line scan. Up to nine have been counted, more or less evenly spaced, and they appear to beat separately from the main signal and alternately change their polarity. During slight beating there is only one well-known local ghost.

During the summer a fairly consistent reduction in the beat was observed at dusk, so much so that a severe beat almost disappeared within an hour, only to return when it was quite dark.

Commercial directional receiving arrays have been tried in order to reduce the seaward pick-up, but to achieve this the main lobe must be turned towards the hills and multiple ghosting is exchanged for the beat. Horizontal aerials give only a slight reduction of the reflection. Although about the same distance from Hessary Tor, and having similar terrain, Tor Bay does not seem to suffer from the effect.

Since May, 1956, the Post Office and the B.B.C. have been investigating the problem without reaching any very definite conclusion. The B.B.C. are of the opinion that the beat is caused by a reflection from the surface of the sea. I cannot entirely accept this theory, as it does not account for all the peculiarities and anomalous propagation effects which have been observed during the past two years.

During the extensive observations of the beat in connection with the tide, weather, and atmospheric conditions, only one consistent factor has emerged, i.e., humidity. Reception conditions are good when the humidity is above 80%, and become sharply worse as the humidity drops below this figure. The only exception is when the humidity is 100% during severe sea mist and low cloud conditions, when receiving conditions may be either very good or very poor. (By good I mean practically no beating.)

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It is my own theory that the reflection may be from the multiple, long, sloping-wire receiving aerials in the Channel Islands, with a path via the troposphere in each direction. Probably there is also a secondary reflection from the sea, as suggested by the B.B.C.

COMMENT.—*Having felt that the effect described above might be associated with weather conditions, "Wireless World" asked a meteorologist, A. H. Hooper, for his views. These are strictly personal opinions.*

THE experiences of Mr. Grant pose several problems and it is necessary to consider how the receipt of a second and delayed signal at the receiver can lead to variations in brightness. One visualizes either a second signal of constant delay but varying strength, or a second signal of varying delay and of strength which may or may not vary. The former condition leads in general to a fixed ghost picture of varying brightness which, with appropriate delay, may coincide with the main picture and so be indistinguishable. The last-mentioned condition gives a ghost picture drifting across the main picture and fluctuating alternately positive and negative in character as the carrier waves of the two signals alternately add and subtract.

When the reflecting object is stationary variations in signal strength can arise due to propagation changes acting on one of the two paths more than the other, or from rotation or eclipsing of the object in a cyclic manner. If, as it appears, the second signal arrives from a seaward direction then its path clearly passes close to the surface, whereas the direct path to Kingsand is well up in the air until the final stage of diffraction over the nearby hilltop. In such circumstances differential propagation effects appear very probable.

However, it is very difficult to visualize any such effect capable of yielding such rapid and continuous fluctuations as those observed. Examples of fluctuations in reflectivity of a fixed object are: (1) vibrations such as of the limbs of an aerial array—this would vary with wind speed, (2) rotation of radar scanning aerials, and (3) eclipsing of rocks out to sea by waves, although not generally at the rate observed in this instance. Moreover, the last effect would vary with state of tide and sea. It has been suggested that certain aerials on the Channel Islands are reflecting energy back toward the South Devon coastline. These islands, however, lie to the south-east and would also radiate energy towards the Tor Bay area (where beating is not experienced).

The one object lying out to sea and capable of re-radiating energy towards the coastline between Start Point and Looe is the Eddystone lighthouse. This is about 20 deg west of south from Hessary Tor and is within the direct line of sight, which passes right over Plymouth, out over the Sound and between the headlands of either side and then on to the lighthouse. Kingsand lies on the western side of Plymouth Sound, just off this line. Neither Hessary nor the lighthouse is directly visible to Mr. Grant, although the lighthouse would be visible from many coastal sites. The reflected signal could possibly vary with rotation of the lighthouse lantern assembly, but this occurs only after dusk. The distance from Hessary to Kingsand is about 27km direct and about 61½km via the lighthouse, giving a delay of about 1.15 lines. This may, in fact, be one of Mr. Grant's ghosts.

Turning now to the possibility of reflection from moving objects, it has been suggested that this could occur from extensive discontinuities in the atmosphere moving at a suitable steady rate and popularly referred to as meteorological fronts. Although the basic structure of meteorological fronts is in the opposite sense to that required, it happens that a proportion of such fronts are immediately preceded by a shallow layer of suitable structure and in such circumstances reflection becomes possible. With full allowance for marginal circumstances the number of fronts passing over Plymouth and possessing this suitable structure is quite few, with the result that the total possible duration of beating due to their presence is small. One would expect beating to occur occasionally for a few hours prior to the passage of each of such fronts, whereas Mr. Grant reports the effect as being semi-continuous.

Another moving source of reflections is to be found in sea waves and swell. The waves, however, will vary in height, length and direction and would only give optimum scatter for the Plymouth area when travelling to or from the S.S.W. Waves would appear —of equal significance—in Tor Bay, and when due to surface wind would often have substantially the same orientation as in the Plymouth area. As the line of propagation towards Tor Bay is perpendicular to that towards Plymouth one would expect any scatter effect to occur simultaneously at both places but of differing magnitude, with occasional extreme cases occurring on a given occasion in only one of the two areas. For the very long sea-wave lengths due to swell coming in from the Atlantic/Biscay area, it is to be expected that, although present off the Plymouth coastline, they would not penetrate into Tor Bay. Presumably it is necessary to demonstrate that reflections from a vast area of scatter sources can add to give an overall wave train of reasonable approximation to the original.

It has been suggested from three separate sets of circumstances that the beating effect increases with the strength of the main signal and depends upon sufficient amplitude of delayed signal. As already remarked, the ratio of the two signals is very likely to be modified by meteorological conditions. This agrees with the appearance of several ghosts when beating is strong. Thus a boosting of the delayed signal by anomalous conditions near the surface is accompanied by a boosting of the reflections from nearby objects which are normally too weak to be visible. This dependence upon refraction is supported, too, by the summer-time variations experienced about dusk when low-level changes due to the setting sun are occurring.

We are faced apparently with an effect involving movement of reflecting (or scattering) objects. The effect is continuous and is apparent over a considerable length of coast. It is claimed that the delayed signal arrives from the general direction of the sea. In such circumstances the one common feature is the surface of the sea itself. However, the effect does not occur along another coastline in largely similar circumstances. The discernible differences between the two sea areas are the presence both of a prominent reflecting object (a lighthouse) and of long-wavelength swell in one of them. Whether this is significant is hard to say, and one wonders whether similar circumstances exist elsewhere.

AWARDS TO AUTHORS

FORTY articles were submitted last year to the panel of judges for consideration for the Radio Industry Council's technical writing prizes. These are awarded annually with the object of encouraging the publication of clearly written expositions on British achievements in radio and electronics. One 25gn premium is given for each of the following:—

"Weather avoidance with airborne radar" by P. L. Stride (Ekco Electronics); *British Communications and Electronics*, April.

"Particle accelerators and their applications" by D. R. Chick (Research Labs., A.E.I.) and C. W. Miller (Research Dept., Metro-Vick); *British Communications and Electronics*, October and November.

"Klystron control system" by R. J. D. Reeves (E. K. Cole); *Wireless Engineer*, June, July and August.

"Two-channel stereophonic sound systems" by F. H. Brittain and D. M. Leakey (G.E.C. Research Labs.); *Wireless World*, May and July.

"Tridac—a research flight simulator" by J. J. Gait (R.A.E.) and J. C. Nutter (Elliott Bros.); *Electronic Engineering*, September and October.

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WORLD OF WIRELESS

Organizational, Personal and Industrial Notes and News

Colour Television

FOR the benefit of members of Parliament special colour television programmes were recently transmitted by the B.B.C. using the N.T.S.C. system modified for 405 lines. The programmes included "live" studio material and film. Through the courtesy of Marconi's, *Wireless World* was able to see one of the transmissions at Chelmsford, where the field strength is only about 1 mV/m.

No receiver adjustments were needed during the half-hour's programme, and results were quite outstanding. In the "live" shots and in some of the film the colour rendering was admirable and greatly enhanced the entertainment value of the programme, compared with black-and-white reproductions. In spite of the fact that the effective video bandwidth is necessarily restricted by the presence of the colour sub-carrier, the apparent definition was so increased by the colour contrast that the final picture appeared appreciably sharper than a monochrome one.

The tests have certainly demonstrated that an entirely adequate colour picture can be obtained with 405 lines and that colour is very desirable. It now remains to develop an economically acceptable system.

Colour at TV Show

SO FAR colour television on the anglicized American standard has been seen in this country by a privileged few. The closed-circuit demonstrations to be given at the forthcoming Television Society Exhibition will therefore be the *pièce de résistance.* Demonstrations are being arranged jointly by Cintel, Bush and Murphy.

The show, in which some 25 exhibitors will be participating, will be held at the Royal Hotel, Woburn Place, London, W.C.1, on March 5th, 6th and 7th. The first day is for members only, but on the other days it will be open to ticket holders from 12.0 to 8.0. Tickets are obtainable free from the Society at 164, Shaftesbury Avenue, London, W.C.2. Applicants must send a stamped addressed envelope.

The exhibitors at the time of going to press are:— Avo, B.B.C., B.R.E.M.A., C. H. Banthorpe, Belling-Lee, Bush, Cossor, Cinema-Television, E.M.I., Edison Swan, Ever Ready, Fielden, G.E.C., Hallam, Sleigh & Cheston, Leyland Instruments, Livingston, Marconi's, Mullard, Murphy, Philco, S.T.C., T.C.M.C., Thorn, 20th Century and W. Vinten.

Physical Society Exhibition

AS IN the past the emphasis at the Physical Society's 41st Exhibition, to be held in the halls of the Royal Horticultural Society, London, S.W.1, from March 25th to 28th, is on new developments in scientific instruments and apparatus, and on possible applications. Tickets are obtainable by sending a stamped addressed envelope to the Society at 1, Lowther Gardens, Prince Consort Road, S.W.7.

The exhibition will be officially opened at 11.0 on March 25th by Professor P. M. S. Blackett, F.R.S., but admission is limited to members and the press until 2.0. It opens on the three following days at 10.0 and closes at 7.0, 9.0, 7.0 and 4.30 respectively. A lecture-demonstration on "The International Geophysical Year" will be given by Sir Harold Spencer Jones at 6.15 on the 25th and another on "Recent Trends in Acoustics" by Professor E. G. Richardson at the same time on the 27th.

The Exhibition handbook of some 300 pages is obtainable from the Society, price 7s 6d, including postage.

International Instrument Show

OVER 50 instrument manufacturers from eight countries are exhibiting at the third International Instrument Show being staged at Caxton Hall, London, S.W.1, from March 25th to 29th. The show opens at 12.0 on the first day and at 10.30 on other days, and closes at 6.30 except on the last day, when it closes at noon. Tickets are obtainable free on application to the organizers, B. & K. Laboratories, Ltd., 57, Union Street, London, S.E.1.

The exhibitors, listed nationally, include:—

Austria: Ludwig Seibold;
Denmark: Bruel & Kjaer, Disa Elektronik, Industrial Controls, Streuers Chemiske Laboratorium;
Holland: Peekel Laboratorium voor Electronica;
Sweden: Magnetic AB, Sivers Lab.;
Switzerland: Metrohm, Hans Muller Barbieri, Vibro-Meter;
U.K.: Advance Components, Avo, G. & E. Bradley, Cambridge Instrument, Cossor, Grayonics, Taylor;
U.S.A.: Advance Electronics Labs., Allen-Bradley, Associated Specialties, Audio Devices, Ampex, Brush, Crosby Labs., Demornay-Bonardi, Electrical Industries, Electro-Measurements, El-Tronics, Heath, Huggins Laboratories, Kay Electric, Krohn-Hite Instrument, Laboratory for Electronics, MB Manufacturing, Narda Corp., Nuclear-Chicago Corp., Panoramic Radio Products, Polarad Electronics Corp., Polytechnic Research & Development, Raytheon, Sperry, Sprague, Texas Instruments, Universal Atomics Corp., Varian Associates, Waterman Products;
Western Germany: Belzer-Werk, Deutsche Elektronik, Hackethal, Erich Herion, Heinrich Schneider, Wissenschaftlich-Technische-Werkstatten.

Balance of Trade

PROVISIONAL figures for radio equipment exported last year show an increase of some 20 per cent on the 1955 figure; £40,3M compared with £33M. As will be seen from the details below, the largest increase was in the direct export of capital goods—transmitters, communication equipment, navigational aids, etc. The striking increase in the export of sound-reproducing equipment continued, and it is worth recalling that the overseas sales in 1947 were less than half a million pounds.

	1956 £M	1955 £M
Capital goods	16.6	13
Sound and television sets	3.8	4
Sound reproducing equipment	7.6	5.7
Components and test gear	8.8	7.5
Valves and c.r. tubes	3.5	2.8
	40.3	33

The industry's import-export trade gap has improved considerably, for whilst exports increased by £7M imports decreased by £2M (from 13.1 to 11.2).

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Monopolies Report

THE Report of the Monopolies and Restrictive Practices Commission on the supply of valves and cathode-ray tubes* is described by the British Radio Valve Manufacturers' Association (B.V.A.) as an historical document, for it bears little relationship to present conditions in the industry as it covers the most prosperous four years (1951-54) in its history.

The commission found that B.V.A. members—who supply 93% of U.K. valves and tubes—so conducted their affairs as to restrict competition.

Since the opening of the investigation in 1954 the terms of reference of the commission have been changed, and it could, therefore, do no more than present a factual report without making any recommendations. It is left for the reader of the 194-page report to form his own opinion as to the effect of the activities of the B.V.A. and its members on the cost and supply of valves and tubes. The report throws a searchlight on the valve industry as a whole and makes interesting reading.

* H.M.S.O. 7s.

U.K. Display in New York

THE offer by the American Institute of Radio Engineers of space at its New York Convention and Show (March 18th-21st) for a collective U.K. display of radio and electronics equipment has been accepted. A number of firms or their U.S. agents are participating in the display in what will be known as the Great Britain Room. The venture is being supported by the R.E.C.M.F. and B.V.A. and among the manufacturers exhibiting are Belling & Lee, Egen, G.E.C., Marconi's, Muirhead, Mullard, S.T.C., and Solartron.

Wireless World will be seen on the stand of British Radio & Electronics, Ltd.

Communications into Electronics

ACCORDING to the annual report, activities of member-firms of the Radio Communication and Electronic Engineering Association are tending increasingly to swing from communications into electronics. During the year under survey an Electronic Data Processing Section has been formed to serve the many firms concerned with computers and allied equipment. An exhibition dealing with data processing is planned for the autumn of 1958.

Proposals were made last year for securing industrial representation in frequency planning. Further discussions with G.P.O. officials have clarified the industry's position.

A revised performance specification for marine radars has now been agreed by all concerned and is being accepted throughout the world. The industry to-day produces radars at the rate of five per day.

Receiver Sales

RETAIL sales of television receivers reached the record number of 1,484,000 last year. Figures issued by the British Radio Equipment Manufacturers' Association show that this was an increase of 11% on the 1955 figure of 1,335,000. The sales of sound receivers dropped by 6% to 982,000, and those of radio-gramophones by 21% to 212,000.

Hire-purchase or credit sales accounted for 50% of television sets sold, 32% of sound receivers, and 56% of radiograms.

April Shows

ARRANGEMENTS have now been made for the allocation of tickets for both the Components Show and the Audio Fair. Double tear-off tickets providing admission to both sections of the Components Show (April 8th-11th, Grosvenor House and Park Lane House, London, W.1) are obtainable free, by engineers and technicians in the "user" industries, research and the Services, from the organizers, Radio and Electronic Component Manufacturers' Federation, 21, Tothill Street, Westminster, S.W.1.

Tickets for the Audio Fair (April 12th-15th, Waldorf Hotel, London, W.C.2) are being distributed through exhibitors and audio dealers. Readers can obtain tickets from the editorial office of *Wireless World*. Applications, stating the day of visit, should be accompanied by a stamped addressed envelope.

Narrow-channel Mobile Radio

FURTHER details now available of the Toronto demonstrations (see page 57, February issue) of the Pye "Ranger" v.h.f. radio-telephone equipment reveal that these embraced both 15-kc/s and 30-kc/s channel spacing with both a.m. and f.m.

The 30-kc/s equipments were oven-controlled at the base stations but not in the mobiles, while the 15-kc/s versions employed crystal ovens for base and mobile transmitter and receiver oscillators and additional i.f. transformers in all receivers.

A comprehensive series of tests was conducted and the general conclusions reached were that 30-kc/s a.m. systems can be operated in the same areas quite satisfactorily. Intermodulation was the main limiting factor, but modulation limiters and filters in transmitters, and the latest reception techniques, go a long way towards eliminating its worst effects. The tests showed that 15-kc/s channel would be practicable with suitable geographical separation.

Direct interference with an a.m. system by an f.m. transmission in an adjacent 30-kc/s channel and at close range was not unduly troublesome, but more investigation seems desirable.

PERSONALITIES

F. S. Mockford, this year's chairman of the Radio Communication and Electronic Engineering Association, has been commercial manager of Marconi's since 1947. He joined the company in 1930, having previously been for ten years in charge of radio at Croydon airport, where he was responsible for much of the early planning and organization of the communication and direction-finding services.

H. G. Sturgeon has resigned from the board of Ultra Electric (Holdings), Ltd., and its subsidiary Ultra Electric, of which he had been chief engineer since 1946. He joined Ultra in 1944 and has been particularly concerned with the development of electronic equipment for the aircraft industry. He was appointed O.B.E. in last year's Birthday Honours.

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Professor F. C. Williams, O.B.E., D.Sc., F.R.S., is to be the first recipient of the Benjamin Franklin Medal of the Royal Society of Arts, which is being awarded annually "to individuals who have attained early distinction, with promise of future achievement, in the promotion of arts, manufactures and commerce." Dr Williams, who is 45 and is professor of electrical engineering in Manchester University, receives it "for his contributions to electrical engineering." He joined the Bawdsey radar research station in 1939 and was employed throughout the war on the development of radar circuitry. In 1946 he resigned from Government service on being appointed to the Chair of electrical engineering at Manchester University, where he has been working on the development of electronic digital computers.

Dr. F. C. WILLIAMS

BRUCE WILKINSON

Bruce Wilkinson, formerly managing director of Electronic Tubes, Ltd., has joined the Plessey Company as divisional manager of the Swindon Components Division. After graduating as a Bachelor of Electrical and Mechanical Engineering from Sydney University in 1929, he joined the engineering department of Amalgamated Wireless (Australasia), Ltd. the following year. In 1946 he resigned from A.W.A., where for some time he was in control of the Research Laboratories, and came to England to take up an appointment as commercial manager of E.M.I. Factories. In 1949 he was appointed director and subsequently managing director of Electronic Tubes, an associated company of E.M.I.

OBITUARY

Marchese Luigi Solari, the last survivor of the original associates of Marconi, died in Rome on February 6th, aged 83. He first met Marconi in 1896, and was present when in July, 1897, Marconi gave the first official demonstration of ship-to-shore transmission over a distance of 18km—then thought to be considerable. In his book "Storia della Radio" he throws some interesting sidelights on early wireless experiments. In it he describes the Solari mercury detector used by Marconi during the transatlantic tests in 1901, during which Solari was at Poldhu.

Air Vice-Marshal O. G. Lywood, C.B., C.B.E., who became a director of Automatic Telephone & Electric Company on his retirement from the R.A.F. in 1946, died on February 3rd at the age of 62. Owing to ill-health he resigned from the board in 1955 but continued as chairman of A.T.E. (Bridgnorth), Ltd. For some time during the last war he was director of signals in the Air Ministry.

T. W. Price, A.C.G.I., A.M.I.E.E., who had been on the staff of Ediswan for 34 years, died on January 28th at the age of 54. He was intimately concerned with the development of cathode-ray tubes, and one of his major post-war contributions was his work on aluminizing. He was a member of the council of the Television Society.

IN BRIEF

In the December **licence figures** issued by the Post Office it is shown that the North West Region (which covers Westmorland, Cumberland, Lancashire and west Yorkshire) has joined the London and Midland Regions in having more television licences than "sound only" licences: London 1,405,884 (1,232,786), Midland 1,102,760 (947,627) and North West 938,402 (925,952). During December the number of television licences throughout the U.K. increased by 136,680 bringing the total to 6,570,097. The overall total of broadcast receiving licences at the end of the year was 14,434,127.

R.C.E.E.A. Council.—The member firms and, in parenthesis, their representatives forming the 1957-58 council of the Radio Communication and Electronic Engineering Association are: B.T-H. (V. M. Roberts), Cossor (F. J. Dellar), Decca Radar (C. H T. Johnson), E.M.I. (S. J. Preston), Ferranti (J. N. Toothill), G.E.C. (M. M. Macqueen), Kelvin & Hughes (C. G. White), Marconi's (F. S. Mockford), Metrovick (L. H. J. Phillips), Mullard (T. E. Goldup), Murphy (K. S. Davies), Plessey (P. D. Canning), Redifon (A. V.-M. E. B. Addison), and S.T.C. (R. McVie).

Schools TV.—Television receivers especially designed for use in schools are announced by two manufacturers. Ferguson have produced two sets, one a projection receiver giving a picture 24-in by 18-in, and the other with a 21-in tube for direct viewing. Cossor's two sets are both for direct viewing, one with a 24-in tube and the other a 21-in tube. Each has a built-in viewing hood to reduce ambient light.

In the note on **v.h.f. coverage** on page 54 of our last issue the Third Programme was listed as being radiated from Wenvoe on 92.1 Mc/s. Although this is eventually to be so, at present the West of England Home Service is radiated on this frequency.

"Output Transformerless Amplifiers."—In Fig. 4 of this article (February issue) the cathode of the lower output valve should be fed from a separate negative h.t. supply as in Fig. 7, and not from earth as shown. In Fig. 9 the cathodes of both the phase splitter and lower output valve should be fed from a separate negative h.t. supply.

National Gramophone Conference.—The bi-annual conference of the National Federation of Gramophone Societies will be held at High Leigh, Hoddesdon, Herts, from April 5th to 7th. Hugh Brittain, of G.E.C., and Percy Wilson, of *The Gramophone*, are among the speakers. Details are obtainable from the Hon. Conference Secretary, 106, Streatfield Road, Kenton, Harrow, Middlesex.

An exhibition of Airmec **electronic instruments** is being held at the Napier Hall, Vincent Street, London, S.W.1, from March 25th to 28th. Tickets are obtainable free on application to Airmec, Ltd., High Wycombe, Bucks.

A conference on **physics of the solid state** is being organized by Professor L. B. Bates, F.R.S., from April 8th to 10th in the Physics Department of the University of Nottingham. Details of the conference, in which contributors from universities and research establishments are participating, are obtainable from the Physical Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7. (Fee 10s.)

BUSINESS NOTES

A **Decca Navigator** chain of mobile stations is to be used in connection with the nuclear tests which will be held in the Central Pacific later this year.

A television camera, measuring under 3-in in diameter and 24-in long, has been produced by **Pye** for installation at Calder Hall. It is fitted on a mechanical grab which is lowered into the fuel channels of the graphite core to remove possible obstructions.

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Ferranti Radio and Television Limited is the name adopted for the new company formed by E. K. Cole, Ltd. (as a wholly-owned subsidiary), to market Ferranti sound and television receivers. It was announced some time ago by Ferranti's that arrangements for the marketing of Ferranti receivers would in future be undertaken by E. K. Cole, Ltd. The head office of the company, which officially commences operation on April 1st, will be at 41/47, Old Street, London, E.C.1.

Emidicta recorders modified to permit a continuous repetition of the recorded message are being supplied by E.M.I. to the Post Office for the extension of the telephone weather service to seven provincial centres. The magnetic disc recording-replay instrument has been modified so that the reproducing head automatically returns along the tracking arm at the end of the recorded forecast.

For some time **Cossor** have had a television "know-how" agreement with Titan Television, Ltd., of Sydney, New South Wales, but they have now acquired a share in the equity of the company, which manufactures both Titan and Cossor receivers.

Closed-circuit television equipment is available on hire from **Audio and Video Rentals, Ltd.**, of 8, Devonshire Mews West, London, W.1 (Tel.: Welbeck 5137), who also rent audio equipment and film scanners. The company, of which Irvin C. Pannaman is managing director, uses Pye industrial television cameras modified for studio use. Prices for hire of a single camera unit, with monitor and sound equipment, range from £7 10s an hour to £75 per week.

Adhesive nameplates, dials, scales, etc., in brass, aluminium, steel or plastic are now provided for the trade by Millett, Levens (Engravers), Ltd., Stirling Corner, Barnet By-Pass, Borehamwood, Herts. (Tel: Elstree 2871.)

Carbion, a new kind of corrugated paper with considerable elasticity and exceptional crush resistance, is now being manufactured by Spicers, Ltd., 19, New Bridge Street, London, E.C.4. In the form of sleeves, it provides **protective packaging** for valves and the like.

The electronics division of Studio Irwin Technical, Ltd., 8, Breams Buildings, London, E.C.4, offers to industry a service for preparing **instruction manuals** and other technical literature.

HARD WORDS.—A writer in the current issue of Design *strongly criticizes "the current collection of formless packages which pass for cabinets," but of this Murphy A262 a.m./f.m. receiver he writes "flowing lines and a definite style give this set a character of its own." He complains of the cautious approach towards cabinet design in this "middle-aged industry" in which manufacturers "instead of continuing to look ahead are looking sideways at each other."*

Mercia Enterprises, Ltd., of 30, Silver Street, Coventry, have been appointed sole concessionaires in Great Britain for the A.E. low-voltage stabilizers manufactured by L'Accumulateur Etanche, S.A., of Brussels, Belgium (see *Wireless World*, February, 1956). Five types are available with current ratings of from 20 mA to 1 amp.

Additional production facilities for components (including transistors), electro-medical and sound equipment and fluorocarbons (PTFE and PCTFE), are provided by **Siemens-Ediswan's** acquisition of a factory at Brantwood Road, Tottenham, London, N.17.

A service department has now been opened at the London office of the **Champion Electric Corporation**, 8, Eccleston Street, S.W.1 (Tel.: Sloane 9838).

Winter Trading Co., Ltd., have opened a warehouse and trade counter at 118, Hampton Road, Ilford, Essex (Tel.: Ilford 6203).

OVERSEAS TRADE

First overseas installation of the new Marconi 16-mm **television film recorder** is for the Bavarian broadcasting authority, Bayerischer Rundfunk. Similar equipment has also been ordered for one of the Australian commercial television stations. The outstanding feature of the equipment is the fast pull-down film mechanism which ensures that each frame of film is moved into position during the blanking period between television frames—from 1.4 to 1.8 milliseconds. (See "Technical Notebook," page 137.)

Last April Automatic Telephone & Electric Co. and Marconi's W.T. Co. concluded an agreement for mutual co-operation in the telecommunications field. A.T. & E. have been awarded a contract for the supply and engineering of a complete v.h.f. frequency-modulated wide-band **radio-telephone link** in Portugal, and Marconi's are providing and installing the radio equipment, which is designed around three new travelling-wave tubes. The installation, which will span the river Tagus at Lisbon—a distance of about nine miles—will initially provide 60 telephone channels and ultimately 240.

RCA Great Britain, an associate company of the Radio Corporation of America, last year exported to the dollar markets $800,000 worth of British-made **audio equipment.** In addition capital equipment exports to the dollar markets were valued at $350,000.

Kelvin and Hughes are exhibiting at the **Leipzig International Fair** (March 3rd-14th) and among the equipment being shown will be a miniature supersonic flaw detector, high-speed pen recorders, electronic temperature controllers, and magnetic recording head.

Equipment for a further chain of four ground stations is to be supplied by Cossor as part of the plan to provide **Gee** coverage for the whole of Western Europe and Southern Scandinavia.

Transmitters, aerials and **studio** equipment for a new **broadcasting station** being built at Omdurman are being supplied by Marconi's. The station, which is to supplement the service provided by the Khartoum transmitter, is to be equipped with two 20-kW h.f. transmitters.

Representation in **Italy** of U.K. manufacturers of sound and television receivers is being sought by Filotecnica Salmoiraghi S.p.a., Via Raffaello Sanzio 5, Milan.

Viet-Nam.—Tenders for the supply of nine h.f. transmitters and 16 communications receivers covering the 2-32-Mc/s band, and sundry other radio and electrical equipment, are invited by Co-Quan Mai-Dich Ngoai-Vien, 29-bis Phan-Dinh-Phung, Saigon. The purchase is being financed by the International Co-operation Administration. Specifications can be obtained from the Viet-Namese Embassy, 12, Victoria Road, London, W.8, or the Export Services Branch, B.o.T., Lacon House, Theobalds Road, London, W.C.1.

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Inexpensive High-Quality

CLASS A PUSH-PULL CIRCUIT WITH 5-WATT RATING

IN this article the design and construction of an amplifier rated to give 5 watts output is given. An inexpensive output transformer is employed, but an adequate stability margin has been provided for a wide range of output conditions.

The author holds that 5 watts is sufficient for high-quality reproduction in the average living room, and in a subsequent article will put forward evidence in support of this view.

The amplifier is suitable for use with the author's gramophone and microphone pre-amplifier described in *Wireless World* for January and February 1955 or with a simplified pre-amplifier to be described later.

THE aim has been, in the design of this amplifier, to keep the cost as low as possible consistent with achieving a performance not audibly inferior to that given by amplifiers of the most luxurious class.

By careful attention to circuit details, wide stability margins are maintained under all likely conditions of use, despite the simplicity of the output transformer, which was specially designed by the author for this amplifier.

The amplifier has an h.t. voltage of 300 V and, with the circuit as shown in Fig. 1, requires a sine-wave input of approximately 4 V r.m.s. for 5 watts output into a resistive load. It is, therefore, suitable for use with the pre-amplifier described in the January and February, 1955, issues of *Wireless World,* or simplified versions of that design[1]. A much simpler pre-amplifier, primarily intended for use with crystal pickups and radio tuner units only, and employing only one valve, will be described later.

By the addition of two electrolytic capacitors and two resistors to the Fig. 1 circuit, 5 watts output may be obtained for a sine-wave input of only 1.4 V r.m.s., the performance in other respects being substantially unaltered.

In the author's opinion, an amplifier rated at 5 watts, provided its performance is clean up to the full output, is quite adequate for domestic reproduction of the highest grade, assuming a loudspeaker of good efficiency—and it should be remembered that moving-coil loudspeaker efficiencies have tended to increase considerably as better magnet materials have been more widely adopted.

Output Stage.—The most expensive component in a high-quality amplifier is normally the output transformer, on which the outlay is sometimes over £5. The cost of an output transformer is dependent on many factors, but a very high ratio of shunt inductance to leakage inductance is always expensive because it necessarily involves dividing the windings into numerous interleaved sections.

In the present amplifier design, the output valves operate under pure class A conditions, and a clean high-frequency performance can consequently be obtained with quite a simple transformer, since there is no need for the leakage inductance between the two halves of the primary to be as low as is necessary under class AB or class B conditions.

[1] "Gramophone and Microphone Pre-Amplifier" by P. J. Baxandall, *Wireless World*, Jan. and Feb., 1955.

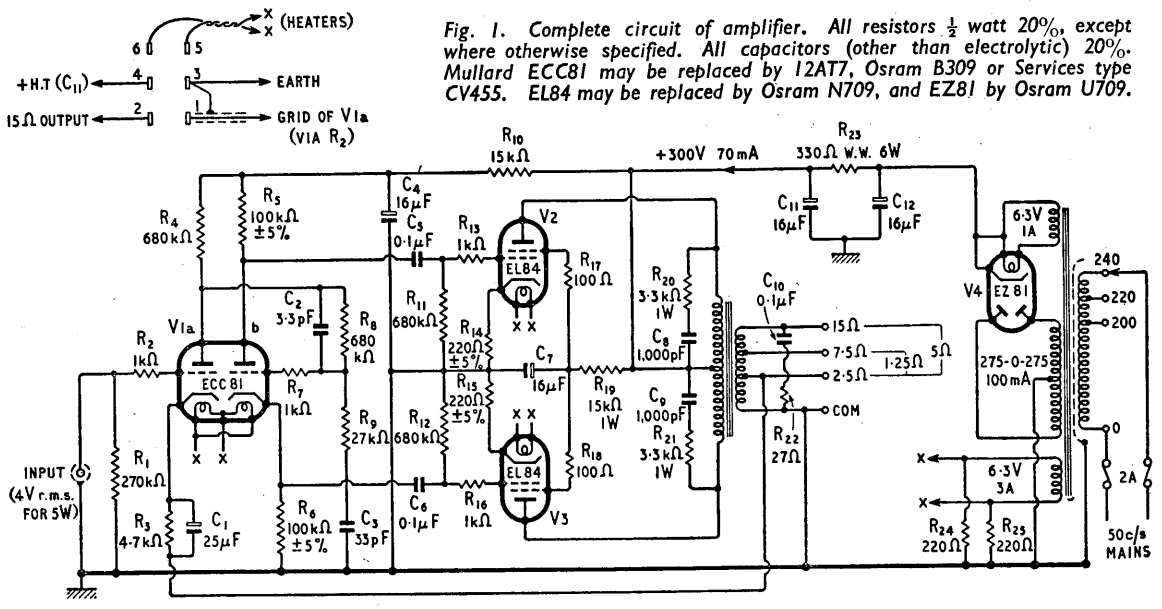

Fig. 1. Complete circuit of amplifier. All resistors ½ watt 20%, except where otherwise specified. All capacitors (other than electrolytic) 20%. Mullard ECC81 may be replaced by 12AT7, Osram B309 or Services type CV455. EL84 may be replaced by Osram N709, and EZ81 by Osram U709.

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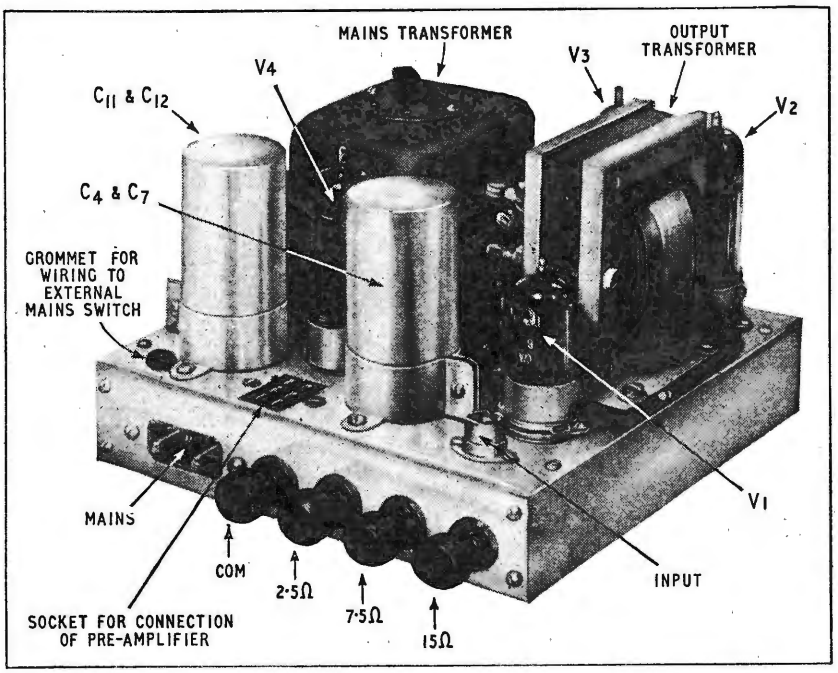
Amplifier

By P. J. BAXANDALL, B.Sc. (Eng.)

The transformer has, in fact, only two primary sections, with the secondary in one section between them.

A further advantage of class A operation is that the audible distortion is less, for a given unweighted total harmonic distortion, than in class AB or class B systems[2]. The efficiency is admittedly lower, but since 5 watts is considered to be sufficient for the purposes for which this amplifier is intended, the lower efficiency is regarded as of little importance.

The stated output rating of 5 watts is actually rather conservative, as will be seen from the measured results given later on; this is intentional, and makes it possible to predict with confidence that *all* amplifiers built to this design will be comfortably capable of giving an output of 5 watts, at adequately low distortion, throughout the frequency range 35 c/s to 10 kc/s, despite the effects of tolerances on components and valves.



General view of amplifier. The chassis in this prototype was made with 18 s.w.g. aluminium and measures 6¾in x 6¾in x 1⅜in.

The nominal d.c. operating conditions give a quiescent anode dissipation in each output valve of 9.5 watts, the maximum dissipation permitted by the makers being 12 watts. With this margin to spare, it is unlikely that the valve rating will be exceeded in any versions of the amplifier built, and a long average valve life should be obtained.

Negative feedback is taken from a tapping on the secondary winding, and not from a tertiary winding as was done in an earlier design by the author[3]. Whilst the use of a tertiary winding is still regarded as an excellent scheme, it unfortunately increases the cost of an output transformer more than might at first be expected for the following reasons:—

(a) The manufacturer has to pay a patent royalty on each transformer.

(b) It would appear to be desirable, when using a tertiary winding for feedback, to adopt a symmetrical winding arrangement with a central partition on the bobbin. With cheaper unsymmetrical winding arrangements, there will be some output at high frequencies from both the secondary and tertiary windings due to push-push even-harmonic distortion current fed to the primary, and it is unlikely that such distortion voltages will be induced equally effectively into secondary and tertiary windings. Consequently, at high frequencies the application of a large amount of negative feedback via the tertiary winding may not reduce the distortion, as measured at the secondary, by as large a factor as would otherwise be the case.

The increase in cost resulting from having to employ a bobbin with a central partition, compared with a simple winding arrangement in which all layers occupy the full winding width, is necessarily quite large, especially since, with the latter scheme, a very satisfactory transformer can be made commercially without side cheeks at all, i.e., using a paper interleaved and impregnated winding on a simple tubular former.

The author is indebted to R. F. Gilson, Ltd., and Partridge Transformers, Ltd., for much useful information relating to other less obvious factors affecting transformer cost. The original output transformer designed for this amplifier used a size of core which was later found to be not very readily available commercially. Moreover, a stack of twice the width of the middle limb was adopted in the interests of improving the ratio of shunt to leakage inductance—but it was pointed out that the use of such proportions would necessitate winding the transformer at lower than normal speed, resulting in a considerable increase in cost.

The final design uses a square stack of size 429 "waste-free" laminations made of ordinary silicon iron material, e.g., Stalloy. Waste-free laminations have proportions as shown in Fig. 2, which permit two "E" laminations and two "I" laminations to be stamped out of one rectangular sheet with no

[2] "The Influence of High-Order Products in Non-Linear Distortion" by D. E. L. Shorter, *Electronic Engineering*, April, 1950.
[3] "High-Quality Amplifier Design" by P. J. Baxandall, *Wireless World*, Jan. 1948.

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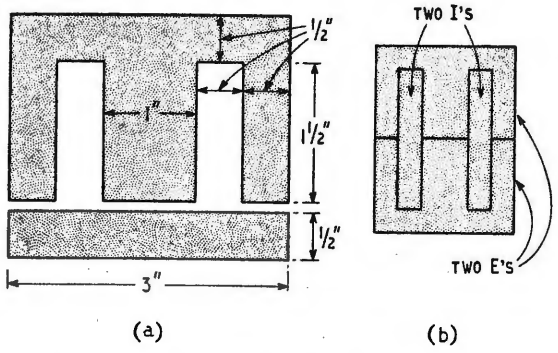

Fig. 2. (a) Dimensions of "waste-free" laminations used in the output transformer. (b) Showing how two "E's" and two "I's" are punched out of one sheet of material, leaving no waste. If grain-oriented material is used, the preferred magnetic direction runs vertically.

waste material left over, thus keeping down the cost. It will be seen from Fig. 2 that these laminations give a rather small winding depth in relation to the cross-section of the iron, compared with typical laminations of earlier design, but this is a help in giving a good ratio of shunt to leakage inductance with simple winding arrangements.

An incidental advantage of having the secondary in only one section, as in the present design, is that simple tappings may be provided for matching different load impedances, thus avoiding the inconvenience of series-parallel interconnection changes between secondary sections and perhaps the necessity for altering the values of components in the feedback network. Furthermore, if, for example, a 15-ohm tweeter is found to be too sensitive when used in conjunction with a particular 15-ohm bass speaker, the tweeter (and its associated cross-over components) may be connected instead across the 7.5-ohm or 5-ohm output terminals. Or, to give another example, a 3-ohm tweeter could be used in conjunction with a 15-ohm bass speaker by connecting it to the 5-ohm, 2.5-ohm or 1.25-ohm terminals, the choice depending again on the relative sensitivities and being made on the basis of aural judgment. In the author's opinion, a frequent cause of unpleasant reproduction is bad balance between the sensitivities of bass and treble speakers, particularly when the treble speaker is the more sensitive of the two; a difference in sensitivities of 6 dB is then enough to give quite strident reproduction, assuming a cross-over frequency in the region of 1 kc/s.

It will be seen from Fig. 1 that an unusual feature of the circuit is that no bypass capacitors are connected across the output valve bias resistors, which results in the application of a small amount of negative feedback to each output valve. Whilst this feedback undoubtedly improves the linearity of each valve, it is nevertheless found that the valve distortion, at a given output voltage, introduced by the complete output stage, in the absence of overall feedback, is not appreciably reduced by the local feedback. This result, perhaps surprising at first, is mainly due to the fact that each valve gives much more second-harmonic distortion than third; the local feedback gives a substantial reduction in second-harmonic distortion, and consequently in total distortion, *in each valve*, but, under the particular operating conditions used, happens to leave the third-harmonic distortion almost unaltered*. The second-harmonic distortion is, however, cancelled out in a balanced push-pull stage, so that the total distortion at the output, mainly third harmonic, is almost unaltered.

Thus, in the present design, the omission of the cathode bypass capacitors does not result in a useful reduction in output stage distortion (in the absence of overall feedback) when matched valves are used. The reasons for omitting the capacitors are, however, as follows:—

(a) Saving in cost and space.

(b) The reduction in forward gain makes it practicable to obtain very good stability margins when applying overall feedback directly from the 2.5-ohm tapping on the output transformer, thus avoiding the need for two resistors which would otherwise be required for giving a suitable value of feedback factor β. Furthermore, with the arrangement used, a sine-wave input of approximately 4 V r.m.s. is required for the full rated output of 5 watts, which is convenient in that it is the same as previously adopted by the author[1, 3].

(c) If the output valves have unequal mutual conductances, the local current feedback largely offsets the effects of this and the performance of the amplifier is affected less by the poor matching of valves than would otherwise be the case.

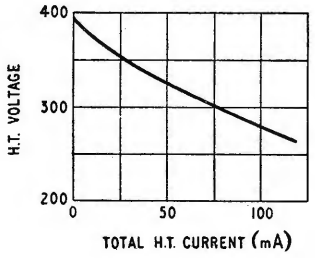

Fig. 3. Regulation curve for power supply shown in Fig. 1, measured at a mains voltage of 225 V on the 220-230 V tapping.

(d) The overload behaviour at high frequencies is made somewhat cleaner by the local current feedback, due to the reduction in push-push second-harmonic current fed to the output transformer primary.

It is appreciated, however, that some readers, not wishing to use pre-amplifiers based on the author's designs, may prefer a higher gain than that given by the Fig. 1 circuit. The necessary modifications are as follows:—

(a) Connect a 50-μF, 12-V electrolytic capacitor across each bias resistor in the output stage.

(b) Connect two resistors in series, of 180 ohms and 100 ohms, between the 2.5-ohm transformer tapping and earth, the 100-ohm resistor going to earth, and take the feedback from their junction.

The performance of the amplifier will not be significantly changed by this modification, except that

* It may be shown that, assuming a valve to introduce only second-harmonic distortion, i.e., to have a simple parabolic transfer characteristic, the application of negative feedback results in the introduction of higher-order harmonic distortion; all harmonics, however, ultimately become negligible if enough feedback is applied. Also, the effect on distortion of applying feedback separately to each valve in the manner adopted is not the same as that of applying the same amount of feedback over the complete output stage; the signal current flowing in each cathode resistor differing from the signal current component that flows through the complete transformer primary, since the former includes also the push-push second-harmonic current which is ineffective as far as the transformer is concerned.

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an output of 5 watts will now be obtained for a sine-wave input of approximately 1.4 V r.m.s. instead of 4 V r.m.s.

Input Stage and Phase Splitter.—The first half of the double triode is a straightforward amplifying stage, d.c. coupled to the second half which operates as a phase splitter. With this arrangement, the only significant elements that give phase lead at low frequencies are the output transformer and the resistance-capacitance coupling between the phase splitter and the output valves; a large margin of stability can then easily be obtained by making the coupling time-constant sufficiently large, which can be done without exceeding a coupling capacitor value of 0.1 μF.

At high frequencies, the attenuation of loop gain is controlled by means of a resistance-capacitance network between the two halves of the double triode† and by further R-C networks across the primary and secondary of the output transformer. Whilst not all of these elements are absolutely essential, it should be emphasized that great care has been taken over this aspect of the design, to secure large stability margins under all likely conditions of load, and also on no load. It is confidently predicted that, if the circuit is built as specified, no troubles whatever will be experienced with instability, even with the most extreme combination of effects due to component tolerances.

The tendency to design and test amplifiers on the assumption of a pure resistance load of the correct value is to be deprecated; for a moving-coil loudspeaker has an impedance that rises considerably at high frequencies, and, when a long speaker lead is used, there will be appreciable shunt capacitance also. The safe procedure, for an amplifier for general use, is therefore to design for large stability margins not only on a 15-ohm resistive load but also in the extreme condition of capacitance load only. In the present design, speaker leads up to at least 100 yards long may be safely used, and no tendency to instability will result even if the speaker at the far end is temporarily disconnected for any reason.

The resistance-capacitance shunt across the secondary is a very effective dodge for increasing the stability margin on no load; when it is present, adding 0.01 μF across the output transformer secondary produces almost no effect on the no-load square wave response, and, in the prototype at least, even 0.05 μF does not produce oscillation. Without the R-C shunt, adding 0.01 μF on no load gives pronounced ringing, and 0.05 μF gives violent oscillation.

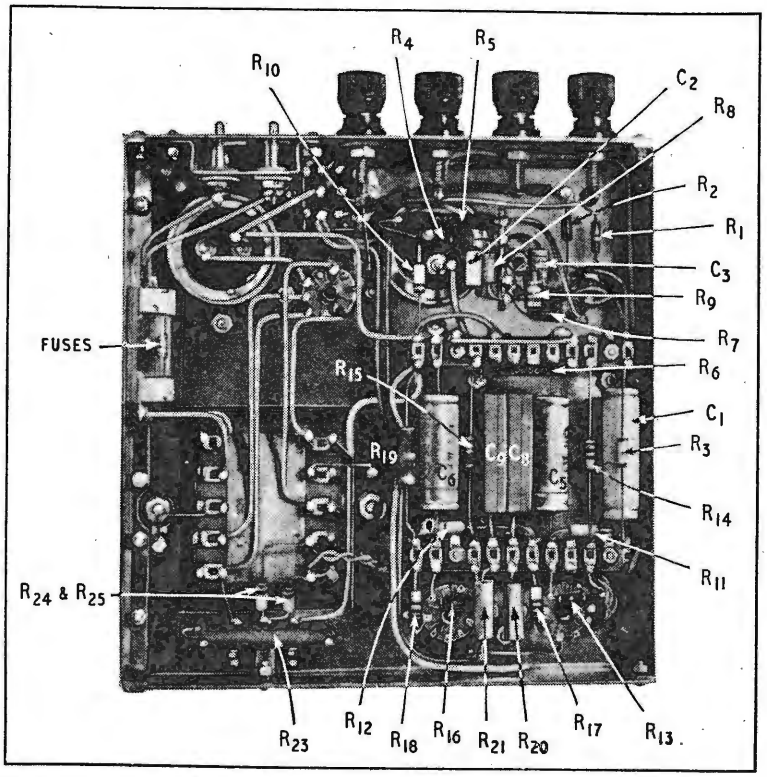
The Power Supply.—In the interests of economy, a capacitor-input rectifier circuit is used, with a smoothing resistor in place of the more usual choke. The regulation curve for the power supply is shown in Fig. 3. Because of the pure class A operation of the output valves, the total h.t. current taken by the amplifier varies by less than 2 per cent between zero and full rated output, so that there is very little fluctuation, with programme volume, of the h.t. voltage available for operating pre-amplifiers, peak programme meters, etc.

With the rectifier valve and mains transformer specified (the prototype was supplied by Stern Radio, Ltd.), a total h.t. current up to 100 mA may be delivered without exceeding the rating of these components. Since the h.t. current taken by the amplifier itself is unlikely to exceed 80 mA, allowing for reasonable effects of component and valve tolerances, h.t. current up to about 20 mA may be safely supplied to external units. Readers wishing to supply more external h.t. load than this should modify the power supply design appropriately; just how this is done is unimportant, so long as the resultant h.t. voltage lies within the limits 280 V to 320 V and does not contain much more than 2 V r.m.s. of 100 c/s ripple.

Construction.—The layout adopted in the prototype is shown in the photographs. The amplifier and its power supply occupy, roughly speaking, separate halves of the chassis, so that substantially the same layout may be adopted by readers who wish to build them as separate units.

The layout is not critical, however, and there is

Layout of components on the underside of the chassis. R_{22} and C_{10} are mounted on top of the chassis between the transformers.



† The arrangement used is preferable, with a triode stage, to the simpler one of shunting a series combination of C and R directly across the anode load. With the latter, as the frequency is raised, the shunt becomes effective in reducing the gain only when its impedance has fallen to a value comparable with the a.c. resistance of the valve, which is very much lower than the value of the anode load resistor. At much lower frequencies than this, however, the resistance-capacitance shunt will severely limit the anode voltage swing that is available without overloading.

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no reason why other layouts should not be used, provided that the following points are watched:—

(a) The components associated with the coupling network between the two halves of the double triode should be mounted close to the valve holder in order to reduce unwanted stray capacitances.

(b) The output stage anode leads should not be allowed to come too near to the wiring of previous parts of the circuit.

(c) The 330-ohm smoothing resistor should be so mounted that its heat will not harm other components.

(d) The transformers should be so positioned that the hum voltage induced into the output transformer by the stray magnetic field from the mains transformer does not give rise to an undesirably high hum output from the amplifier. In case of doubt, a simple experiment may be done before building the amplifier, as follows. Connect the primary of the mains transformer to the mains and the secondary of the output transformer to a loudspeaker. On moving the transformers about, it will be found that, even when they are very close together, there are certain positions in which the hum is almost zero. One such position is with the axis of the windings on the mains transformer passing through the centre of the output transformer at 90° to the axis of the windings on the latter. In the author's layout, the transformers are not quite arranged in this ideal way—to have adopted it would have required an increase in chassis size—but the hum, whilst just noticeable on first switching on, falls to a completely negligible level as soon as the amplifier warms up and feedback becomes effective in reducing the hum output.

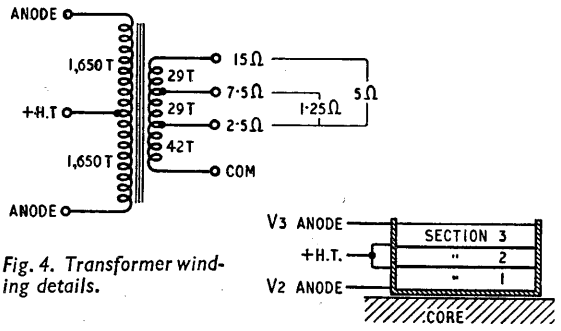

Fig. 4. Transformer winding details.

It will be seen that in the prototype tag strips have been used instead of a group board. The type of tag strip employed, which has tags at ¼in spacing, has much to recommend it for home-constructed equipment; it is easily cut to length, tags may be removed where necessary for fixing screws, and two strips may be mounted at just the right distance apart to accommodate the particular components used in an elegant manner. The strip is readily available, e.g., from G. W. Smith & Co., 3, Lisle Street, London, W.C.2.

A 6-pin socket* is provided for making connections to pre-amplifiers, etc. The amplifier input lead in the corresponding cable should be separately screened, but none of the other leads in this cable need be screened. In the prototype, a Belling-Lee coaxial socket is also provided for the input, which may be found convenient in cases where the input source does not obtain its power supply from the present amplifier. A further provision is that one pin on the 6-pin socket is connected to the 15-ohm output terminal of the amplifier; this enables a simple peak programme meter, whose circuit will be given later, to be built into the pre-amplifier unit, if desired, but supplied with signals from the output transformer secondary.

Large screw terminals (Belling-Lee Cat. No. L. 1004/11) are used for the loudspeaker connections, and whilst these are more expensive than a socket strip, they are, in the author's opinion, much the most desirable form of connector for the purpose. Socket strips tend to lead, sooner or later, to the use of match-sticks!

Transformer Details.—A transformer suitable for this amplifier may be obtained from R. F. Gilson, Ltd., and is known as Type WO 893. A similar transformer may be obtained from Partridge Transformers, Ltd., and is known as their type P4076. For readers who prefer to wind their own transformer, the winding details are given below.

Core

1in stack of laminations (inter-Services size 429A) as Fig. 2, 0.014-in thick in ordinary silicon iron such as Stalloy (111A), Silcor II (29A) or Strantranis No. 1 (43A). The laminations may be interleaved alternately in the normal manner.

The frequency down to which the amplifier is capable of delivering its full rated output may be appreciably lowered by using "Unidi" or "Unisil" laminations. These are made of grain-oriented silicon iron, such as is used normally in C-type cores, and have superior magnetic properties in the rolling direction but not at right-angles to this direction. With "waste-free" laminations, however, as may be appreciated from Fig. 2, the laminations may readily be stamped so that, throughout the major part of the magnetic circuit, the flux is in the preferred direction in the material. Despite the technical advantage of this material, the author doubts whether its use in the present amplifier would confer any *audible* advantage whatever on any kind of musical programme. A transformer with "Unidi" laminations, otherwise similar to the normal model, can be supplied by R. F. Gilson, Ltd., and by Partridge Transformers, Ltd., who describe it as their type P4077.

Bobbin

To suit core, ⅛in material.

Windings

Section (1). 1,650 turns of 38 s.w.g. enam., in nine or ten layers, with 0.002 or 0.003-in transformer paper between layers.

Cover with three layers of 0.005-in Empire cloth before winding section (2).

Section (2). In three layers, with 0.002 or 0.003-in paper between layers, as follows:—

1st layer—42 turns of 22 s.w.g. enam.
2nd layer—29 turns of 20 s.w.g. enam.
3rd layer—29 turns of 20 s.w.g. enam.

All connections between layers to be brought out as shown. (Fig. 4.)

Cover with three layers of 0.005-in Empire cloth before winding section (3).

Section (3). As section (1) and wound in same direction.

(*Continued on page* 113)

* The socket may be obtained from Painton & Co., Ltd., Kingsthorpe, Northampton, and has the catalogue number 500472. The corresponding cable entry plug has the number 500198.

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Cover the outside of section (3) with Empire cloth for protection.

If the secondary is wound with the bobbin rotating in the same direction as for the primary sections, then the feedback will be negative, as required, when the outside of section (3) is connected to the anode of the output valve whose grid is fed from the cathode of the phase-splitter.

The home constructor is recommended to bring out the actual winding wire for connections to all sections. The alternative method of soldering flexible (stranded) lead-out wires to the primary winding, whilst reducing the danger of lead breakages after completing the winding, introduces lumps into the winding where the taped joints occur and hence makes uniform winding on a simple hand winding machine (e.g., hand-drill) considerably more difficult. It is not hard, given reasonably careful handling, to avoid breaking the 38 s.w.g. leads during construction of the transformer, but connection to the external circuit should be via a tag board or terminal board so arranged that the 38 s.w.g. leads to the back of the board cannot readily be damaged.

Tests

The following figures were obtained on a prototype from R. F. Gilson, Ltd.:

Total primary resistance	422 ohms
Total secondary resistance ..	0.45 ohm
Leakage inductance, measured at at 1,000 c/s across whole primary with whole secondary short-circuited	54 mH
Leakage inductance, measured at 1,000 c/s across one half of primary with the other half short-circuited	77 mH
Total primary inductance, measured at 50 c/s and 10 V r.m.s	60 H

(To be continued)

Automatically Tuned Direction Finder

Pilot-Operated Navigational Aid for Large Aircraft

RADIO direction finding plays, and will undoubtedly continue to play for some time, an essential role in air navigation over the principal air routes of the world. A new direction finder was recently announced by Marconi's; it takes the form of an automatically tuned DF set (ADF) designed especially to meet the requirements of modern high-speed passenger and transport aircraft. A miniaturized version for Service aircraft is also made.

The Type AD712, as the civilian version is called, was shown as a prototype at Farnborough last year and is now in production form. It is particularly suitable for pilot operation as it is necessary only to initiate the tuning by "clocking up" the frequency of the land station required on a small controller and the receiver makes all necessary tuning adjustments and displays the bearing, accurate to within ±2 degree, on a 0– to 360 degree bearing indicator.

This simplicity of operation is made possible by a unique tuning system involving the use of some 36 crystals. Setting up a frequency on the controller selects a particular combination of crystals, which, by the sum and/or difference of their frequencies, provides a reference frequency with which is compared a continuously tunable oscillator (the first mixer). The difference frequency is used to control a tuning motor driving a chain of dust-iron cores which form the tuning elements of the set.

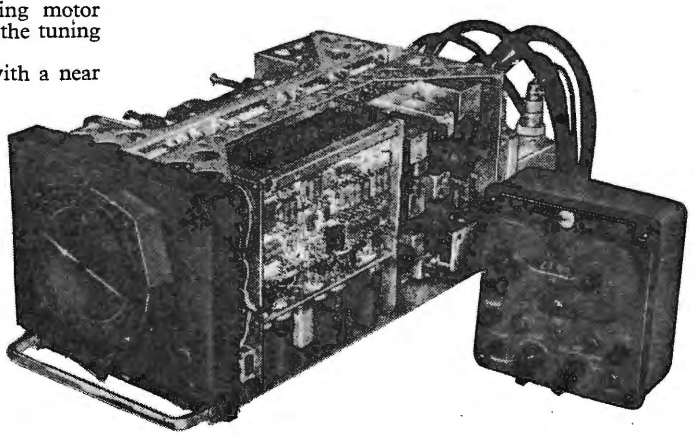
The receiver is a double superheterodyne with a near normal first i.f., but a rather low second one. The wavebands covered are 100 to 415 kc/s and 490 to 1,799.5 kc/s and selection of a frequency within these limits can be effected in steps of 0.5 kc/s. Two bandwidths are provided; ±700 c/s and ±1.5 kc/s, measured between −6 dB points.

For ADF operation signals are fed to the receiver from a pair of dust-iron cored crossed loops housed in a thin fibre-glass moulding of suitable contour and aerodynamic form for mounting on the outside of the aircraft skin.

Signals from the crossed loops are fed to a quadrantal error correction unit, thence to a goniometer and after suitable "processing" the resultant signal is mixed with the output from an omni-directional "sense" aerial and passed to the i.f. and detector stages. The modulation is used to drive the goniometer search coil to the null-signal position. The goniometer motor drives also the pointer of the DF indicator on the front of the receiver and a selsyn-type system repeats the bearing on a remote indicator in the pilot's cockpit.

A low-power audio output provides aural reception with headphones, or over the aircraft's intercom, as required. Ground beacons, radio ranges and Consol are receivable and the set can be used, within its frequency ranges, as a communications receiver.

For a ±2 degree overall DF accuracy the field strength required at the aerials is 25 μV/m; and for communications 5 μV/m with 30% modulation of the signal give a signal/noise ratio of 6 dB. Power requirements are, 140 VA at 115V, 400 c/s and 1 A at 28 V d.c.



Marconi Type AD712 ADF set removed from its case. The remote controller is shown on the right.

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The Short-Circuited Turn

DETERMINING THE CONDITIONS UNDER WHICH IT MAY BE HARMFUL, USEFUL OR JUST HARMLESS

By THOMAS RODDAM

IF a quick skimming through the standard books is any guide, nobody seems to have bothered very much about the short-circuited turn, although it leads a life which at first glance is comparable to that of Jekyll and Hyde. The faulty low-frequency coil does not prevent us using a brass slug to tune our high-frequency coils. Why is there this split behaviour? Where does the division between the useful and the useless lie?

The obvious thing to do is to draw the actual circuit of a coil with a short-circuited turn and calculate its impedance. If the result can be expressed in simple terms we should be able to build up a behaviour picture: if the result is just a long mathematical expression we shall have to work out enough special cases to provide the foundation for a general pattern. Fortunately, it turns out that, if you make the right approach, the result can be expressed in terms which are already familiar in quite a different context. And then we see that this is just what we might have expected.

The basic circuit is shown in Fig. 1(a). The wanted circuit is an inductance L_1 having resistance R_1. This is itself a simplification, because shunt losses are neglected, and at high frequencies the series resistance will not be constant. However, it is better to understand a simplified system than to fail to understand the phenomena at all. The short-circuited turn, which may be more than a single turn, of course, is taken to be the separate winding L_2, imperfectly coupled to L_1, and this is considered to have what we may call a self-resistance of R_2.

The transformer L_1L_2 can be replaced by its equivalent circuit to give the network of Fig. 1(b). This is one of the equivalents given some time ago in *Wireless World*[1]. Moving over to the other side of the ideal transformer we get the form shown in Fig. 1(c). Now we are ready to write down the impedance of our coil with its short-circuited turn.

The parallel combination of k^2L_1 and $k^2n^2R_2$ has an impedance Z of

$$1\Big/\left(\frac{1}{j\omega k^2L_1}+\frac{1}{k^2n^2R_2}\right) = \frac{j\omega L_1k^4n^2R_2}{j\omega L_1k^2+k^2n^2R_2}$$

so that the total impedance is

$$R_1+j\omega L_1(1-k^2)+j\omega L_1k^4n^2R_2/(j\omega L_1k^2+k^2n^2R_2)$$

$$=R_1+j\omega L_1(1-k^2)+j\omega L_1k^4n^2R_2(k^2n^2R_2-j\omega L_1k^2)/(\omega^2L_1{}^2k^4+k^4n^4R_2{}^2)$$

$$=R_1+\omega^2L_1{}^2k^6n^2R_2/(\omega^2L_1{}^2k^4+k^4n^4R_2{}^2)+j\omega L_1(1-k^2)+j\omega L_1k^6n^4R_2{}^2/(\omega^2L_1{}^2k^4+k^4n^4R_2{}^2)$$

After some multiplying and rearranging we come to the form:

$$Z=R_1\frac{1+\frac{\omega^2L_1{}^2}{n^4R_2{}^2}\left(1+\frac{n^2k^2R_2}{R_1}\right)}{1+\frac{\omega^2L_1{}^2}{n^4R_2{}^2}}+j\omega L_1\frac{1+\frac{\omega^2L_1{}^2}{n^4R_2{}^2}(1-k^2)}{1+\frac{\omega^2L_1{}^2}{n^4R_2{}^2}}$$

Still, you may think, pretty intractable. But now let us substitute $f^2=\omega^2L_1{}^2/n^4R_2{}^2$ and $r=n^2k^2R_2/R_1$ and we have

$$Z=R_1\frac{1+(1+r)f^2}{1+f^2}+j\omega L_1\frac{1+(1-k^2)f^2}{1+f^2}$$

In this expression "f" is proportional to frequency. If f is zero, the impedance reduces to $R_1+j\omega L_1$, just as we should expect, because the transformer action to the short-circuited turn is ineffective. If f is very large indeed, the impedance is $Z=R_1+n^2k^2R_2+j\omega L_1(1-k^2)$. Looking back to Fig 1(c)

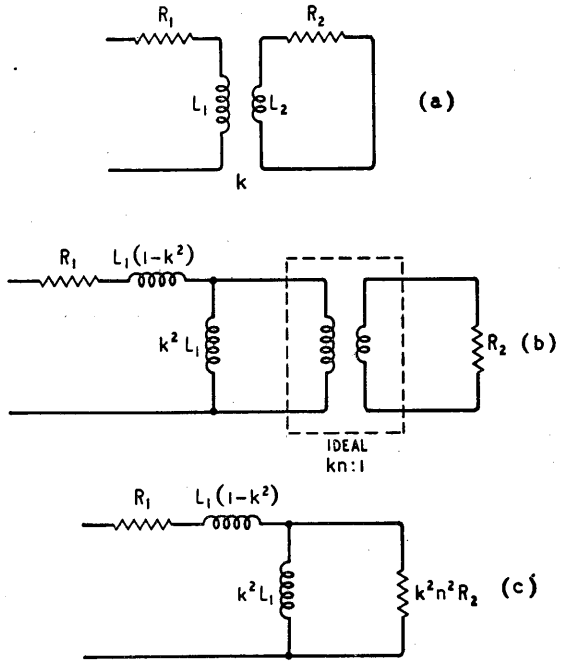

Fig. 1. (a) The short-circuited winding L_2 has a "self-resistance" of R_2. It can be transformed via (b) to the simple network (c).

[1] "Some Electrical Theorems," by W. Tusting, November 1954

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this again is just what we should expect, because $j\omega L_2$ is so large compared with $n^2k^2R_2$ that we can neglect it. Can we easily find out what happens in between?

The resistance and reactance terms each have the form

$$M=(1+a^2f^2)/(1+f^2)$$

If we can deal with this, we can deal with each of the components of Z. Let us take logarithms:

$$\log M=\log (1+a^2f^2)-\log (1+f^2)$$

You may already have recognized the form of the expression: you may recognize the form log $(1+f^2)$. Just in case you have not connected it up, consider the circuit of Fig. 2. For this circuit

$$\left(\frac{V_1}{V_2}\right)^2=1+\omega^2C^2R^2$$

and if we put $\omega^2C^2R^2=F^2$
the frequency response is 10 log $(1+F^2)$ decibels.

This is a very familiar shape indeed. In some articles on feedback problems in *Wireless World*[2], I described how straight-line approximations could be used to sketch out characteristics of this form. You can find a summary of this in Langford-Smith, "Radio Designer's Handbook" (p. 363). In very simple terms, we assume that if F is less than unity we neglect it: if F is greater than unity, take $(1+F^2)\approx F^2$ so log $(1+F^2)\approx 2$ log F. This is a straight line on graph paper using a logarithmic scale for frequency. A rather better sketch is obtained by noting that at F=1, 10 log $(1+F^2)\approx 3$ which gives a point at the corner to enable it to be rounded off.

With this connection established, the form of M becomes familiar too. It is a "step" characteristic, the shape we introduce in our feedback amplifiers to manœuvre past a point of inadequate stability. In its simplest approximation form it consists of two horizontal sections, M=1 and $M=a^2$, joined by a sloping line. The corners are at $f=1$ and $f=1/a$. All we need to do, then, is to draw this pattern, remembering to use logarithmic scales. It isn't, of course, necessary to hunt out log-log graph paper for this. I prefer to use centimetre squares, scaled in octaves. This is much cheaper, and it gets over the difficulty that only too often one has a supply of one maker's log paper one year, and another maker's the next. Centimetres are always the same size.

Now let us turn back to Z. The corners of the resistance characteristic are at $f=1/\sqrt{(1+r)}$ and $f=1$, and the corners of the reactance at $f=1/\sqrt{(1-k^2)}$ and $f=1$. For the sake of an example, let us take

$r=3$

and $(1-k^2)=0.25$, i.e., $k^2=0.75$, $k=0.865$.

The step heights are: for R, 4

for L_1, 4

and the corner frequencies: for

R, $f=1$ and $f=\frac{1}{2}$

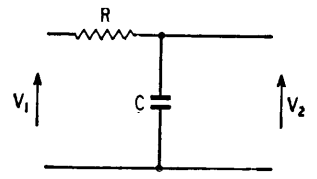
L, $f=1$ and $f=2$.

Fig. 3 shows the simplified shapes which are obtained.

We are now in a position to look more generally

[2] "Stabilizing Feedback Amplifiers," March 1951.

Fig. 2. For this network $V_1/V_2 = 1+j\omega CR$, so $|V_1/V_2|^2=1+\omega^2C^2R^2$.



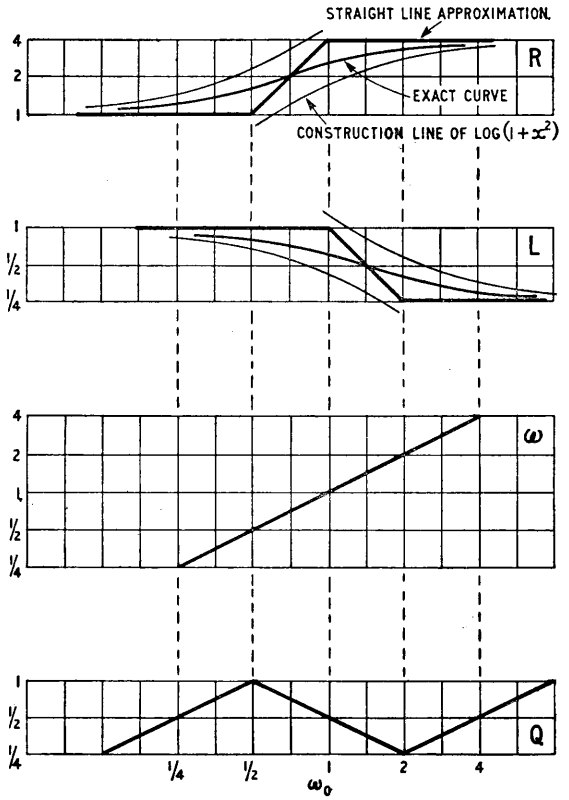


Fig. 3. Typical shapes obtained using the straight-line approximation method for the conditions discussed in the text.

at what happens. The key frequency is obviously given by $f=1$. Looking back we see that

$$f=\omega L_1/n^2R_2$$

so that the key frequency ω_0 is given by

$$\omega_0=n^2R_2/L_1$$

Below this frequency the resistance has already been increasing, while the inductance has stayed unchanged: above this frequency the inductance is falling, but the resistance has already reached its limit.

The next important frequency to consider is given by $f^2=1/(1+r)$ so that it is just

$$\omega_2=\omega_0/\sqrt{(1+r)}.$$

This tells us where R starts to rise.

The third important frequency is where $f^2=1/(1-k^2)$ when L reaches its final value. It is, of course, $\omega_2=\omega_0/\sqrt{(1-k^2)}$.

Before going on to explore these details, let us just add to Fig. 3 a line showing frequency as a function of frequency—a straight line, as you might expect, and then a simplified graph for $Q=\omega L/R$ which on a log-log scale gives us log Q=log ω+ log L−log R.

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To draw this we simply add and subtract, as indicated, the lines already drawn. We see that Q increases up to ω_1, with $Q \propto \omega$, then decreases with frequency between ω_1 and ω_2 with $Q \propto 1/\omega$ and finally, above ω_2 increases with frequency again. This Q-factor is not, in general, the true Q of the coil, because it takes account only of the copper loss, and even this is assumed to be constant. The effect of the short-circuited turn is, however, clearly shown. In general terms it reduces the limiting Q by a factor of $(1-k^2)/(1+r)$.

Some Numerical Examples

Now, perhaps, we might go on to discuss some of the implications of our results. If we have a true short-circuited turn, by which I mean that L_2 is actually part of L_1, $nR_2=R_1$ because the area of the conductor is the same for the two windings (or parts of the winding). Consequently

$r=n^2k^2R_2/R_1=nk^2$.

In a low-frequency coil, k^2 will be near enough to unity not to be worth keeping in the picture, so that $r \approx n$. The key frequency is n^2R_2/L_1 or nR_1/L_1.

Let us try some numbers: a coil for a low-frequency filter might well have an inductance of 100 mH, with 1,000 turns and a resistance of 10 ohms. At 1,600 c/s, this coil would have a Q of 100. It is, in fact, a good coil. Now let us assume we have a short-circuited turn. The resistance will start to rise at a frequency

$\omega_1=\omega_0/(1+n)^{\frac{1}{2}}$ (since $r=n$)

$=nR_1/L(1+n)^{\frac{1}{2}}$

$\approx n^{\frac{1}{2}}R_1/L$ (since n is large enough for $1+n \approx n$).

Thus $\omega_1=n^{\frac{1}{2}}10/0.1=100n^{\frac{1}{2}}$.

The maximum value which n can take is 1,000, when a single turn is shorted. Then $\omega_1=3{,}000$, roughly, and the frequency is 500 c/s. If a block of 10 turns is short-circuited, $\omega_1=1{,}000$, and the frequency is about 160 c/s. The values of ω_0 lead to frequencies of 16,000 c/s and 1,600 c/s. As we have seen, it is only above the key frequency ω_0 that the inductance starts to fall. A test at 1,000 c/s, then, would show the correct inductance but very high losses. As we have already seen, the resistive term tends towards $(1+r)$ times its normal value, so that on the basis of the straight line approximation the resistance will be 10,000 or 1,000 ohms for the two values of n at ω_0.

Now let us look at the brass tuning slug. In a high-frequency coil we might make $k^2=\frac{1}{2}$, and since the slug is very much thicker than the wire of the coil, nR_2 will be much less than R_1. To get some figures, let us consider a 10-turn coil, and a slug made up of 10 turns in parallel. Then $R_2=R_1/100$ and $r=\frac{1}{2}\times 100\times\frac{1}{100}=0.5$. The resistance of this coil will be increased by 50%, while the inductance is brought down to one-half its original value. To adjust the coil we withdraw the slug, and as we make k smaller, L will rise and R will fall. If we only need a 10% reduction in L we can take $k^2=0.1$ so that R only rises by 10%. That certainly is not too expensive.

These two examples confirm the result which we might have derived from our expression for the impedance: in most practical situations the first parameter to examine is r. If r is small, nothing much will happen to the loss of the coil. If k is very small, nothing will happen to the inductance either, but a small value of k does not necessarily mean a small value of r. It helps, though, as you would expect, because if the short-circuit isn't coupled to the coil it can't do much harm. Keeping R_2 low keeps r small, so that a silver-plated slug will be slightly better than a brass one. But for a small adjustment, k will look after this, and as we saw, you may only be losing 10%. It is interesting to notice that if we had altered our 10 parallel turn slug to a two-"turn" slug, each turn made up of 5 standard turns, although n^2 would have fallen to 25, R_2 would have risen to $R_1/25$ and r would not have been affected.

Having checked for good or bad by examining r, a test for the active frequency region begins with the determination of ω_0. This tells you whether your application is likely to find the shorted-turn disturbing the inductance or the resistance.

In all the discussion above we have used the straight line approximation. Of course, the whole analysis is based on an approximation, but for the benefit of those who want to see how much the smooth-curve solution deviates from the straight-line form, I have added the smooth curve to Fig. 3. The basic smooth curve can be found as in Fig. 7.55D of "Radio Designer's Handbook." and a general survey is given on pages 363–365. All that need be done is to add the smooth standard curves instead of the approximation. The straight line approximation is at its worst near the corners of the characteristic, so that Fig. 3 makes it look just about as bad as it can be. With a little practice it becomes fairly easy to sketch in the rounding and to produce a freehand curve quite close enough to the correct one. Fig. 7.55F of the above shows how this sort of technique comes out in practice.

Screening Problems

Can we make use of all this work for any other purpose? Life is not all slugs and defectives. One fairly obvious application is to the problem of screening coils. The screen is just a short-circuited turn, and the problem resolves itself into the determination of k and R_2. The only simple expression I have been able to find is given by Terman ("Radio Engineer's Handbook," 1st Edition, p. 71, equation 87). He gives an approximate expression for the coefficient of coupling between two coaxial concentric coils as $k=a^2l/A^2x$, where a and A are the radii of the inner and outer coil, and $2l$ and $2x$ are their respective lengths. If we assume the screen to be twice the length of the coil itself and the screen radius to be twice the radius of the coil, this gives us $k=\frac{1}{8}$. From what we have already seen, the limiting inductance is $L_1(1-k^2)$ so that we lose rather under 2% of our inductance. If we also assume that the screen is the same kind of conductor as the wiring we get back to the expression $r=nk^2$.

For a 10-turn coil, then, $r=0.156$. In this particular case the inductance drops 1.56% but the resistance goes up by 15.6%.

Unfortunately these figures are in violent disagreement with those given in Section 10.1 vii of Langford-Smith. The RCA curves for k^2 rather suggest a misprint in Terman, because there would be fair agreement if Terman's expression were actually for k^2. This leads us to the conclusion that the effect of the screen is to drop the inductance about

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12% and increase resistance to more than double its initial value.

It is rather a pity that there is this disagreement. However, the RCA curves for k^2 can always be used, and the expression for r enables us to get some idea of what will happen to the losses. We can also get some idea of the frequency range over which L will be varying. This is important, because we often find it convenient to test a coil at one frequency and use it at another. A screened coil may have a different inductance when the frequency is changed. When measuring the self-capacitance, too, we assume that the inductance itself is constant. With a screened coil this is not necessarily so.

One feature of our results not yet discussed is that there is a worst value for the quantity n^2R_2. If n is fixed, this means that there is a worst value for R_2: if nR_2 is fixed, the case of a short-circuit on a uniform winding, there is a worst value of n. To examine this effect we may proceed to differentiate the expression for Z: I haven't done this, because it seems to be one of the easiest ways to cover a lot of paper without arriving at any results. Let us try a rather more roundabout approach, confining our attention for the moment to the resistance. In fact, it is only the resistance which behaves in this way, but the proof of that I shall leave to the reader.

We have

$$R = R_1 \frac{1 + (1 + r)f^2}{1+f^2} = R_1\left(1 + \frac{rf^2}{1+f^2}\right)$$

The only term which varies is the factor $rf^2/(1+f^2)$. This is a maximum if $(1+f^2)/rf^2$ is a minimum. So now we need only think about

$$\frac{1}{rf^2} + \frac{1}{r}$$

and this is

$$\frac{R_1}{n^2k^2R_2} \cdot \frac{n4R_2^2}{\omega^2L_1^2} + \frac{R_1}{n^2k^2R_2} = \frac{R_1}{k^2}\left[\frac{n^2R_2}{\omega^2L_1^2} + \frac{1}{n^2R_2}\right]$$

$$= \frac{R_1}{k^2\omega L_1}\left[\frac{n^2R_2}{\omega L_1} + \frac{\omega L_1}{n^2R_2}\right]$$

It is fairly well known, and fairly easy to prove, that a quantity $(a+1/a)$ has a minimum value when $a=1$. A quick numerical check will show how very plausible this is. Therefore if

$$\frac{n^2R_2}{\omega L_1} = 1$$

the resistive term is a maximum. Since

$$\frac{1}{rf^2} + \frac{1}{r} = \frac{2R_1}{k^2\omega L_1}$$

at this point, the circuit resistance will be

$$R = R_1(1 + k^2\omega L_1/2R_1).$$

If you like bringing in Q, you can write $\omega L_1/R_1 = Q$ giving $R = R_1(1 + k^2Q/2)$ and the peak occurs when

$$\frac{n^2R_2}{R_1} = Q$$

An application of this part of the analysis can be found in "Recent Developments in Long-Distance Telephony," A.C. Timmis, *J.I.E.E.*, Vol. 78, p. 601, June 1936.

In an appendix we find Fig. 4 (based on Fig. 15, *loc. cit.* p. 615). This shows how the resistance term in the basic characteristics of telephone cable varies with the thickness of the copper tape used for screening. The screen acts as a short-circuited turn coupled to the long narrow loop formed by the pair of conductors. Roughly speaking, R_2 will be inversely proportional to the thickness of the screen. As we expect, there is a worst value of R_2 for any particular frequency. As the frequency is increased, this maximum occurs at higher values of R_2, or lower thicknesses. And the figure shows, too, that the incremental resistance at the maximum is roughly proportional to the frequency of the maximum. All in accordance with theory.

Other Applications

Although only a very rough picture can be obtained, the theory of the short-circuited turn does give some idea of why you need to use thinner laminations in an iron-cored coil if you want to get a good Q at higher frequencies. Each lamination, is, in section, a small shorted-turn. The thinner the lamination the higher the value of ω_0, the key frequency. Different material resistivities alter ω_0 too: the results are only of value in providing a general concept, because the current distribution across the lamination alters with frequency, and R_2 is by no means constant.

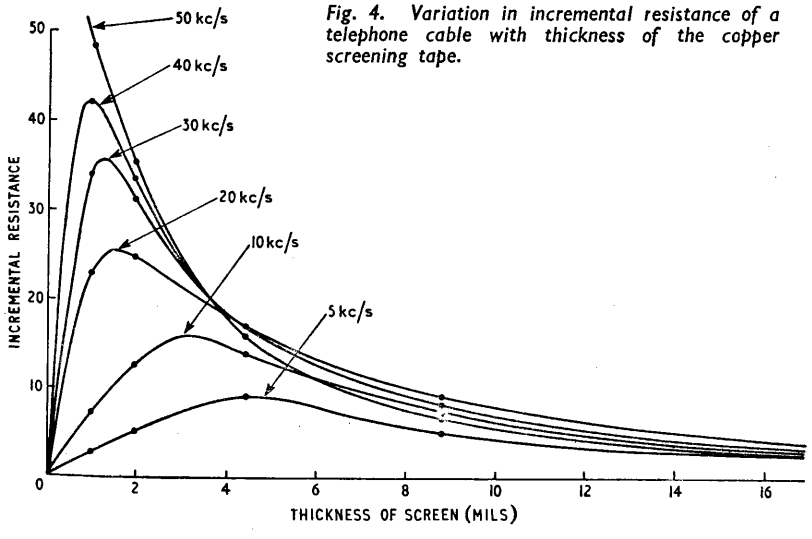

Fig. 4. Variation in incremental resistance of a telephone cable with thickness of the copper screening tape.

As any reader who has progressed this far will have seen, the short-circuited turn is worth a detailed study. The theory has wider application than would appear at first sight; it shows us that there are some mathematical operations which come in useful for all sorts of purposes and it leads to an agreeably tidy solution. There is, of course, no great new discovery involved. All this article has attempted is a tidying up operation: it has certainly tidied up my own ideas on this pleasantly ordinary problem.

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LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Colour Television

WHILE the B.B.C. were transmitting some NTSC-type colour television for the benefit of M.P.s a few weeks ago I happened to look in at the monochrome version, and I must say I was not at all impressed by the compatibility. The pictures had an unaccustomed soft look, which might have been due to sub-carrier interference (visible on my set), or to some fault of gamma correction, or to the loss of luminance detail by gamma correction described by Dr. White in your February issue. It would be interesting to hear an explanation from the B.B.C.—and also if they were using a "notch" filter to reduce sub-carrier interference, or some other method.

I would certainly mark the effort as "8+" or "well tried," but for me, at any rate, compatibility has got to be perfect. Such pictures would not be at all acceptable as a regular thing—although I must say I enjoyed the show rather better than the normal B.B.C. programmes! (Perhaps it was necessary to "sell" compatible colour to the hon. Members.)

London, S.E.22. K. R. McALISTER.

WHILST I am in no position to discuss the attitude of our General Post Office in relation to the possible transmission standard for colour television signals, R. F. Colvile may like to know that a similar state of affairs to that prevailing here exists in the United States and throughout a large area of Europe.

The American approach is rather interesting as it is a guide to the mysteries surrounding the preoccupation with a 405-line colour TV standard in this country. In short, the ATT and Bell networks convert the NTSC full-specification signal to a "Narrow Band NTSC Signal," the relative details are that the colour sub-carrier is shifted to 2.66 Mc/s approximately. Apart from scanning rates, therefore, the total occupied spectrum (3 Mc/s) closely resembles that currently used in the B.B.C. tests.

Speaking personally, I feel that it will be quite a long time before the Television Advisory Committee reaches a final decision, and even then they will be influenced by the viewpoint of the major manufacturers and the overall economic situation.

Winston Electronics, Ltd., Shepperton, Middx. G. LEVINE.

EXISTING systems of colour television are governed by two constraints: (a) the receiving apparatus is assumed to use a three-component method of reconstructing the coloured picture and (b) the transmission is required to be compatible.

If it were not for these constraints, the obvious method of transmitting a colour picture which would still be usable on monochrome receivers would be to transmit luminance, hue and saturation, the first according to the existing monochrome standards. But hue and saturation are not convenient variables for the reconstruction process. So far as I know the only variable-hue device is an adaptation of the Kerr cell, which implies a projection receiver, and there is no direct variable-saturation device.

In a linear system the luminance, hue and saturation signals could be translated in the receiver into red, blue and green intensities, but this is excluded if gamma correction is applied at the transmitter to anything more than the simple luminance signal. It could be removed from the latter by an inverse gamma correction at the receiver before setting about the construction of three colour components. In these days when crystal diodes are quite cheap, is it really impracticable to require the manufacturer of the receiver to incorporate in it the non-linear circuit which is needed to compensate the gamma of the picture tube? One could then transmit true luminance and colour signals.

A realistic assessment of the importance of absolute compatibility depends on a forecast of transmission schedules. Will all transmitters go over to colour for the whole of their transmissions as soon as a colour system is established, or will there be at least an intermediate stage in which some programmes will still be transmitted in monochrome? Will the cost of colour receivers remain so far above the cost of monochrome receivers that there will still be a market for the latter, and will programme production costs be much higher in colour than in monochrome?

Only in the light of answers to these questions can one decide whether the whole future of colour television should be prejudiced for the sake of absolute compatibility.

Birmingham. D. A. BELL.

Scale Distortion Again

WHILST I fully agree with the arguments put forward by your reviewer, M. G. L., in his reply to Stanley May (p. 30, your January issue) I think he did less than justice to Vox Productions in his review of their record DL130, "This is High Fidelity."

The main part of the booklet issued with the record was a photo-copy of the American version. But a number of comments that seemed to be required to adapt the text to British practice was made in a foreword which the British company asked me to write. In that foreword the point was specially made that most British acoustic engineers did not concur in the American advocacy of a "compensated gain control" based on the Fletcher-Munson curves.

It has always seemed to me that far too much importance has been attached to these curves (which after all are only an empirical expression of the average of a number of observations made during a particular series of experiments); and, indeed, that they have been applied as authoritative evidence in circumstances which are outside their terms of reference. They purport to show the intensities of pure tones of equal loudness at different frequencies, the loudness being based on the average of the judgments of the persons who were concerned in the experiments. But it does not by any means follow that if a piece of music is reproduced at a volume level greater or less than the original (whatever that may mean!) the frequency response should follow the contour of a Fletcher-Munson curve. Logically, there is no necessary relationship between the two. An entirely different set of experiments would be necessary to determine (even if it could be determined with any precision) what are the rules that should be applied to reproduction at different volume levels in order that the result may sound natural.

The beginnings of such a research were started by G. A. Briggs and his associates at his Festival Hall demonstrations. They showed conclusively that the intensity level which reaches our ears in a concert hall is much smaller than we had previously assumed, and indeed that it is possible to achieve the same level in one's home without the music sounding over-loud, even to the ladies. But they told us nothing at all about the desirable frequency response for reproduction in the

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home, whether at that intensity or at higher or lower intensities.

Assumptions which are extrapolations of observations in particular experiments are very risky in the field of hearing. Who, for example, could have supposed on *a priori* grounds that when a complex sonorous vibration from a loudspeaker is presented to the ear it will be resolved, not into a set of constituent tones, but into a series of groups of tones, one group representing a violin, another group a piano, another an oboe and so on? Why doesn't the ear do something analogous and sort out what one might term (for shortness) the stereophonic components in the vibration?

I suggest that until we have specific *ad hoc* evidence in this matter of loudness *v.* frequency response we had better reserve judgment and simply adjust our controls to please our womenfolk.

Technical Editor, PERCY WILSON.
"The Gramophone."

Information Theory and Broadcasting

SO the human mind is to be turned into a "black box" of calculable capacity for insertion into a communication chain! That thought (editorial comment, your January issue) rather shocks me. Anyway, I doubt if you have succeeded in showing how Information Theory can be applied directly towards improving broadcast programmes. All the same, I agree that the programme people might benefit from studying the underlying philosophy.

Take the information content of television pictures. V. J. Cooper, after pointing out (your April 1956 issue) that the vision bandwidth is 100 times greater than that of the accompanying sound, went on to assert we get very poor value for the extra Mc/s. Your editorial set me trying to verify Mr. Cooper's assertion. After spending quite a lot of time in watching typical programmes, my conclusion was that he did not exaggerate. Indeed, there were occasions when the *semantic* information content of the picture seemed to be a negative quantity! The sound transmission alone sometimes evoked in my mind a visual image that turned out to be more satisfying, pleasing or appropriate than the picture seen on the screen when I reopened my eyes. And I am not supposed to be a highly imaginative type.

Reading, Berks. C. J. STRATTON

THE editorial of your January issue advances strong arguments which show that the B.B.C. should make a complete reappraisal of the regional broadcasting system.

I had hoped that when the v.h.f. network spread it would carry a cosmopolitan programme of the most general interest, leaving the medium waves for the Regions, but, alas that was not to be. I fear that the eagerly awaited v.h.f. station at Rowridge will carry the West Region service instead of the far more apposite London programmes.

Romsey, Hants. B. JAMES.

Television Interference

IN your February issue "Diallist" refers to, and expresses some surprise at, a few cases reported from the Leeds area of interference from the Holme Moss v.h.f. sound transmissions with television reception from the same station.

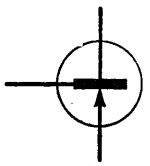
This is most likely second-channel interference on television receivers having non-standard i.fs. in the 20-Mc/s region with, of course, their local oscillators "high." There are still quite a few of these receivers in use, and the second-channel rejection of some is unfortunately not all that could be desired. The trouble can usually be overcome by the use of a simple stub rejector consisting of a section of coaxial feeder cut to the appropriate length and connected at the aerial input to the receiver. The alternative of fitting some sort of second-channel rejection circuit inside the receiver or changing the i.f. is not always convenient, but may be necessary in some cases.

Second-channel interference has also been experienced by viewers in the Norwich area since the v.h.f. sound station sharing the same site as the Norwich television station was brought into operation in December. Here the trouble affected television receivers having i.fs of 19.5 Mc/s (sound) and 16.0 Mc/s (vision), which when tuned to Channel 3 for reception of the Norwich station 56.7 Mc/s (vision) and 53.25 Mc/s (sound) are prone to second-channel interference on vision from the v.h.f. Light Programme transmitter on 89.7 Mc/s and on sound, but to a lesser degree, from the v.h.f. Third Programme transmitter on 91.9 Mc/s. The B.B.C. has given advice on the problem, and thanks to the energetic efforts of the radio trade and of local Post Office engineers the complaints that have been received are being dealt with effectively. None of this trouble is, of course, being experienced on television receivers with i.fs of 38.15 Mc/s sound and 34.65 Mc/s vision, which have now been adopted as standard by the radio industry.

Engineering Information
Department, B.B.C. L. W. TURNER.

Transistor Symbols

I FIND I have been guilty of unconscious plagiarism in submitting the transistor symbol shown in your last issue. Something very similar appeared earlier in the December, 1956, issue of the *Journal of Scientific Instruments* (see sketch) in a paper by Bane and Barber. My apologies are nevertheless tinged with satisfaction at getting this support from such an august body as The Institute of Physics (which publishes the *Journal*) and from the authors, who are N.P.L. people.



London, S.E.5. JAMES FRANKLIN.

Etymological Inexactitude

"CATHODE RAY" rebukes me in his letter (Feb. issue) for treating the word "data" as singular. In so doing I was, strictly speaking, as fully guilty of an etymological inexactitude as he himself is in his letter when he uses the word "panchrome" instead of the puristically proper word "pantochrome." No doubt he is consistent and takes his offspring—or, more correctly, little Fluorescences—to the "panmime" which pedantic people still call a pantomime.

But, seriously, although we are obviously both trying to follow modern usage, I have by far the stronger case. Nowadays the word "datum" has a special positional meaning as in the sentence "sea level is the datum for measuring mountain height." In English, it is no longer the singular of "data." The word "data" has virtually become a singular noun in its own right in the same way as the word "agenda," to which, Sir, you so rightly call attention. Whoever heard the Chairman of a committee say "Gentlemen, the agenda *are* rather long to-day"; and if there be only one item on it, does he call it an agendum?

"FREE GRID."

Peak or R.M.S.?

I HAVE always been under the impression that there was a convention that all audio and r.f. voltages which would normally be measured by a valve voltmeter were expressed as peak values, and I have for a number of years used a valve voltmeter which starts with a diode probe.

I notice lately, however, that there is a tendency for other forms to become popular. For instance, the instru-

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ment shown on page 611, December issue, measures the mean or average value, although it may be calibrated to read r.m.s. or peak on some definite waveform. There is another one advertised on p. 144 (Dec.) which may be similar.

Many makers of recording tape and recorders do not state whether the figures they quote for erase, bias and signal voltages are peak or not, and I think I have seen one tape advertisement where r.m.s. figures are quoted.

This all seems to be adding up to some confusion.

Bideford, Devon. THOMAS G. WARD.

Guarantees

I AGREE with your February editorial that guarantees are usually unsatisfactory.

Our firm's guarantee reads "Departures from the specification during the first 12 months of proper use will be corrected free of charge." This at least has the merit of brevity, and our customers evidently like it.

Servomex Controls, Ltd. R. C. STEEL.
Jarvis Brook, Sussex.

Radar Displays

I REGRET to take issue with anything which Dr. Eastwood has to say on the subject of radar displays. I believe that the substance of his comments in his letter in your issue for December is perfectly correct until it makes the claim that the first perfected comprehensive fixed-coil display system used in this country was developed and produced by Marconi's Wireless Telegraph Company in association with the R.R.E.

There is perhaps little credit in any case in being first in the field, but for the record I should like to point out that the Liverpool harbour radar, designed and developed by A. C. Cossor Limited for Sperry Limited, incorporates a fixed-coil display which has proved satisfactory in operation since it was officially commissioned at an opening ceremony on July 3rd, 1948. The first M.T.I. radar in operation at London Airport, also designed by A. C. Cossor Limited, which was installed there in July, 1953, incorporated a fixed-coil display and interscan provision for a C.R.D.F. presentation.

A. C. Cossor Ltd., K. E. HARRIS.
London, N.5.

COMMERCIAL LITERATURE

Signal Sources, including noise and pulse generators, take pride of place with some 90 pages in the 1957 catalogue of measuring instruments from Marconi Instruments of St. Albans, Herts. There are also instruments for measuring voltage, power, frequency, f.m. deviation, distortion, field strength, Q and standing waves. An industrial section includes X-ray apparatus, moisture meters and pH meters. The catalogue is lavishly illustrated with photographs and functional diagrams.

Non-Soldered Connections by means of "taper receptacles" or small tubular units of silver-plated brass into which tapered pins are inserted. These and many other types of terminals (for soldering) and accessories are listed and illustrated in a catalogue from Harwin Engineers, Nibthwaite Road, Harrow, Middlesex.

Tape Amplifiers, for recording and reproduction, designed for various well-known makes of tape decks and also for double-channel stereophony. Four models, as well as two other amplifiers for sound reproduction, are described (with specifications) in an illustrated catalogue from Shirley Laboratories, Worthing, Sussex. Overseas distributors are Sound Diffusion (London), Duracraft Works, Portslade, Sussex.

Electronic Reading Machine for recognizing printed characters at 120 per second and recording the information on punched cards or tape, or magnetic tape, for computer input. This is one of the new projects under development outlined in a review of progress by the Solartron Electronic Group for 1956. Available from the company at Thames Ditton, Surrey.

Interlocking Storage Trays for small components, suitable for factory assembly benches. A new "midget" range, moulded in phenolic material, is illustrated in a leaflet from Precision Components (Barnet), 13, Byng Road, Barnet, Herts.

Polythene Sheets in gauges between 0.01in and 0.125in. Physical properties and applications of "IRIDON-1000" are described in literature from the Iridon Division of Commercial Plastics, 1, Avery Row, Grosvenor Street, London, W.1.

Coated Soldering Bits with thin layer of an iron alloy over the copper to protect it against oxidation. Claimed to last 10 times longer than conventional bits. Various sizes and shapes, for screwing or plugging into irons, with notes on use and care, are given on a leaflet from the Hexacon Electric Company, 276, W. Clay Avenue, Roselle Park, N.J., U.S.A.

Barium Titanate Pickup cartridges claimed to be impervious to distortion from humidity and temperature changes. Change of styli (normally sapphires) by turnover method. Weight: 5 grammes. Frequency response curve and other performance data given in a leaflet from Technical Ceramics, Wood Burcote Way, Towcester, Northants.

A.M./F.M. Signal Generator covering 7.5Mc/s to 230Mc/s. Internal frequency modulation: 1,000c/s with fixed deviation of ±60kc/s, or mains frequency with variable deviation of 0 to ±150kc/s. External modulation: between 20c/s and 20kc/s for deviation up to ±150kc/s. Amplitude modulation: 10% or 30% at 1,000c/s. Crystal calibration at 5-Mc/s intervals. Specification on a leaflet from Advance Components, Roebuck Road, Hainault, Ilford, Essex.

Pencil-Type Soldering Irons. A range of six Oryx models for low voltages between 6V and 50V, lengths 6-7in and bit sizes $\frac{1}{16}$ to $\frac{3}{16}$in, are described in a leaflet from Antex, 3, Tower Hill, London, E.C.3. Mains step-down transformers are also available.

Subminiature Electrolytic capacitors, suitable for transistor circuits and hearing-aids. Five new types (CE58) with capacitances from 0.25 μF to 6 μF and working voltages of 25 V to 1.5 V, measuring only $\frac{5}{8}$in long × $\frac{1}{4}$in diam., listed in Technical Bulletin No. 51 from The Telegraph Condenser Company, North Acton, London, W.3. Also a miniature range, $1\frac{1}{16}$in × $\frac{3}{8}$in and 2-100 μF in Bulletin No. 52.

Crystal Set using a germanium diode. Leaflet from the British Distributing Company, 591, Green Lanes, Harringay, London, N.8.

Moving-Coil Pickup, with diamond stylus for microgroove and sapphire stylus for standard records. Response: 20 c/s-16 kc/s constant velocity on microgroove. Compliance: better than 6×10^{-6} cm/dyne. Stylus pressure: 5 grammes. Leaflet on model GMC5 from The Garrard Engineering and Manufacturing Company, Swindon, Wilts.

Miniature "3000" Relay, with twin silver contacts, buffered springs, and coil consumption in the region of 0.075-0.2 watts, depending on contact arrangements required. Coil resistance, any value up to 5,000 Ω. Overall size, $1\frac{1}{2}$in × $1\frac{3}{16}$in × $\frac{1}{2}$in. Made by PAR of Nottingham and distributed by D. Robinson and Co., 58, Oaks Avenue, Worcester Park, Surrey.

Valve Retainers of various types. A manual listing a large number of CV valve types and their commercial equivalents with appropriate data on retainers and top-cap connectors. From Electrothermal Engineering, 270 Neville Road, London, E.7.

Simplified Relay, for a.c. up to 440 V and d.c. up to 110 V, departs from the normal "pile" method of mounting the contact blades and has them brought out directly on to insulating panels. This makes it possible to remove any set of contacts without disturbing the others. Leaflet from Electrical Remote Control Co., East Industrial Estate, Harlow New Town, Essex.

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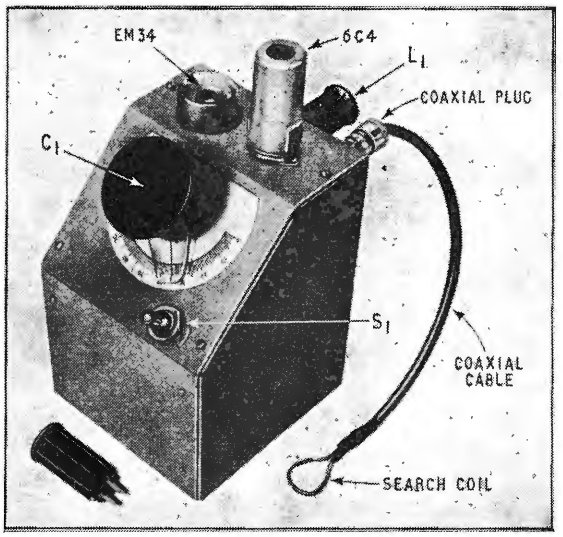
Grid-Dip Oscillator

NOVEL APPLICATION FOR A CATHODE-RAY TUNING INDICATOR

By H. B. DENT



Form of construction adopted for the GDO described in the text. The power supply occupies the base part and the oscillator the top part.

THE grid-dip oscillator can be likened to an absorption wavemeter used in reverse, for instead of absorbing energy in the process of measurement it has energy extracted from it. The absorption principle is used with oscillating circuits and the grid-dip method with quiescent circuits, the two being complementary in test gear.

Basically, a grid-dip oscillator (GDO for short) consists of a tunable r.f. oscillator with a very sensitive current measuring meter in its grid circuit. Two typical arrangements are shown in Fig. 1. Fig. 1 (a) will be recognized as one of the Colpitts family, while (b) obviously belongs to the Hartley group.

The instrument derives its name from the manner of operation. When the coil L is coupled to the inductive element of a non-oscillating circuit a "dip" in grid current occurs whenever the two circuits come into resonance.

No circuit changes are needed to either Fig. 1 (a) or Fig. 1 (b) to convert them into absorption wavemeters: all that need be done is to lower the anode voltage until the valve ceases to oscillate. There is some regeneration when the value is just short of the oscillating point, but this will improve rather than impair the performance as an absorption wavemeter.

When used as a grid-dip oscillator the changes in grid current are often quite small, especially when v.h.f. circuits or awkwardly placed h.f. circuits are involved which preclude coupling the GDO tight enough. Consequently very sensitive current meters are required in the grid circuit. Despite the manifold usefulness of this type of test set it is not always in such constant demand as to justify tying up an expensive microammeter for this one purpose. Plug-in meters can, of course, be employed but the writer has always disliked the idea of having to search round for a lot of loose items before a test set can be used.

What seemed to offer a solution to the problem appeared in the September issue of the New Zealand journal *Break-in*. It was a description of a grid-dip oscillator built round an EM80 cathode-ray tuning indicator. The really unique feature of this design is that the "triode" part of the EM80 is used as the r.f. oscillator, while the "magic eye" functions as the indicator of resonance. The circuit is shown in Fig. 2 and, with a suitable set of coils, is said to cover a frequency range of 80 kc/s to 200 Mc/s.

A "breadboard" version of Fig. 2 was assembled using an EM34 in place of an EM80 as the former was, but the latter was not, available and the EM34 was said in the original article to be a likely substitute. A few minor changes in the circuit were made; for example, the two "anodes" of the EM34 were strapped together and joined to a single anode resistor, also the "frills" S_1, S_2, R_2 and R_4 were omitted. These are included in the original design to enable the unit to be used either as a GDO or as an absorption wavemeter.

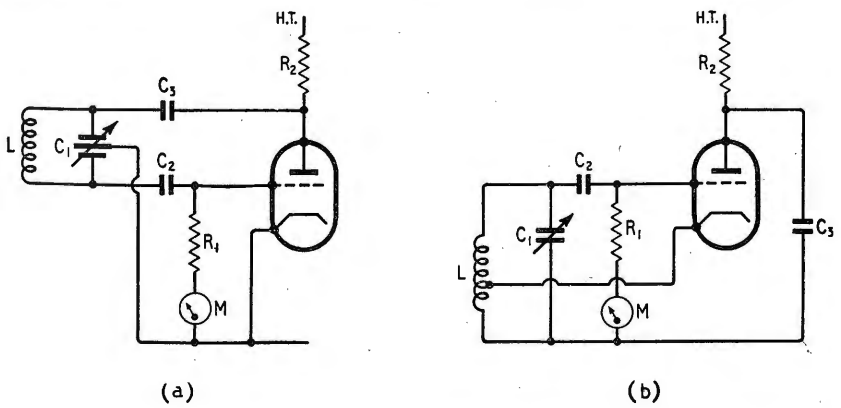


Fig. 1. Two typical circuits used for grid-dip oscillators; (a) is a Colpitts and (b) a form of Hartley sometimes called an "electron-coupled" oscillator.

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Despite the temporary layout being rather unsuitable for v.h.f. operation it was possible to obtain oscillation up to about 120 Mc/s. The lower frequencies were not explored, but it is reasonable to assume there will not be much difficulty in this region. The temporary layout served to confirm the practicability of the scheme and the "eye" winked most satisfyingly whenever an external circuit was coupled to the coil (L) and tuned through the resonant frequency of the oscillator, or *vice versa.* The only drawback (if it can be regarded as such) was that the EM34 required an h.t. supply of the order of 200 V for the "valve" to oscillate, and this seems also to be the requirement of the EM80 as the h.t. line was 250 V. Even with 200 V h.t. the anode resistor of the EM34 had to be dropped well below 100 kΩ to achieve oscillation in the v.h.f. bands. The general sensitivity appeared to be comparable to that of an orthodox GDO circuit using a sensitive grid-current meter.

As it was desired to limit the h.t. to 120 V or so the tuning indicator idea was embodied in a GDO built round a 6C4 triode oscillator, as shown in Fig. 3. In this case the tuning indicator, an EM34, is operated by the rectified d.c. voltage which in all "grid-leak" oscillators appears as a negative bias on the grid of the valve and coexists with the grid current, so that indirectly the tuning indicator responds to "dips" in grid current. Thus there is no need to find another name for the unit. As the quiescent voltage on the grid of the EM34 is negative the indicator segments normally tend to close and open whenever a "dip" in grid current occurs in the oscillator.

Using 120 V h.t., and the circuit values in Fig. 3, the 5-V segment of the EM34 can be made to close fully with a suitable cathode tapping on L_1. The h.t. consumption is very light, being about 2.5 mA at 120 V. Of this the 6C4 takes 2 mA and the EM34 0.5 mA. Of course, the EM34 is not as brilliant as when operated at the normal 250 V but it is adequate for all normal purposes. The h.t. and l.t. are supplied by a small double-wound transformer T_1 (home made) giving 130 V and 6.3V at 0.4 A, an RMO

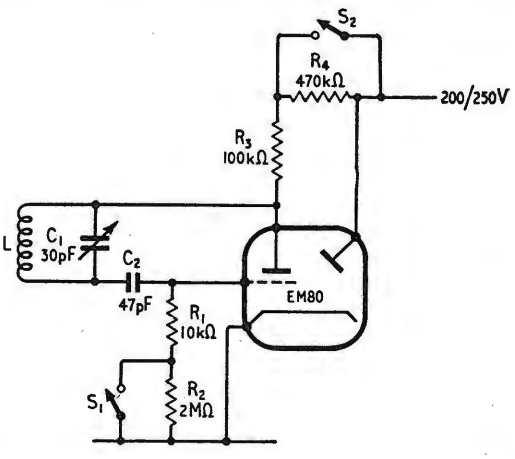
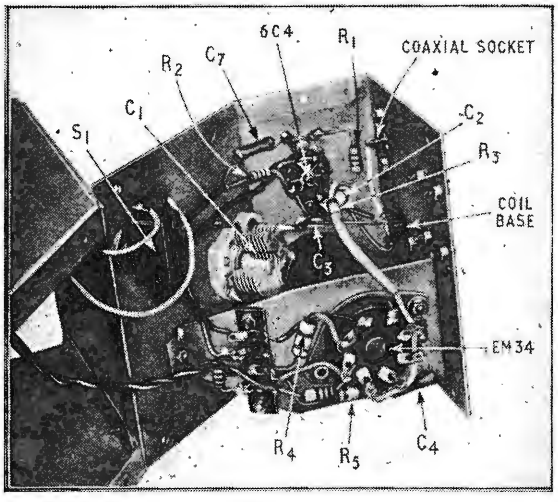
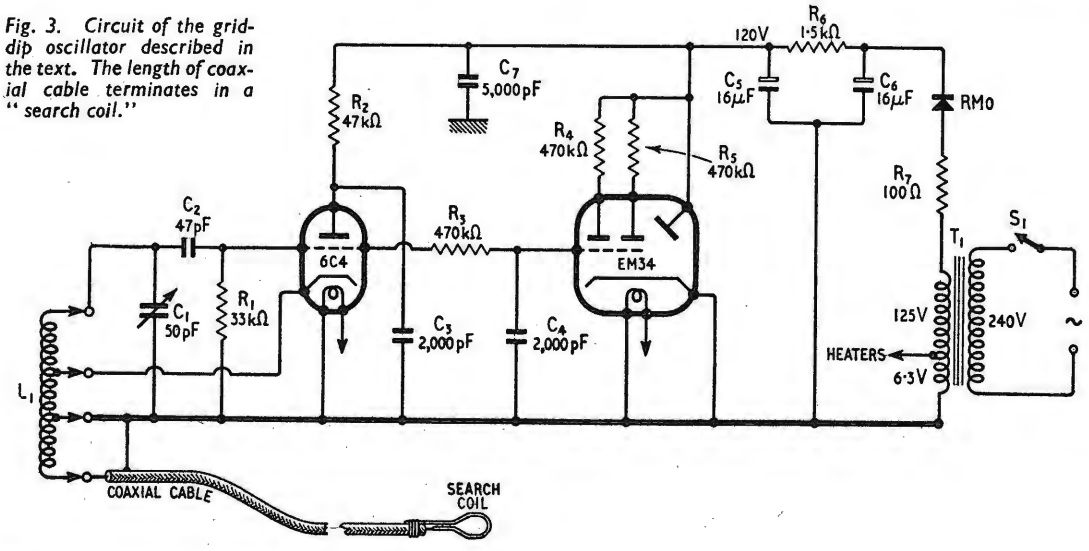


Fig. 2. Circuit of a grid-dip oscillator built around a single cathode-ray tuning indicator (described in September 1956 Break-in).



The oscillator is laid out to enable all connecting leads to be kept short. The tuning indicator is seen in the background.

Fig. 3. Circuit of the grid-dip oscillator described in the text. The length of coaxial cable terminates in a "search coil."



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"Centercel" rectifier, and the smoothing network shown. Incidentally C_5 and C_6 are 150-V working electrolytics.

The length of coaxial cable terminating in a loop shown in Fig. 3 is included to enable this GDO to be used in conjunction with v.h.f. equipments where it is often difficult to obtain a tight enough coupling to produce a measurable "dip" in grid current. The cable terminates in a coaxial plug and the "coupling coil" part of L_1 is taken to a coaxial socket on the back of the unit.

The "search coil" idea is not without its snags but the only troublesome one is that the cable has a self-resonance determined by its construction and length. If the resonant frequency falls in the tuning range of the oscillator absorption occurs and the indicator "winks," just as it will when coupled to any other tuned circuit. However, with a 10in length of "Standard Aeraxial" cable the resonant frequency fell just above 120 Mc/s, which is the highest frequency covered by the experimental unit. No originality is claimed for the "search-coil" idea as the writer has a recollection of seeing it used somewhere before, but neither the place nor the details can be recalled.

Two L_1 coils have been made so far; one covers 52.5 to 120 Mc/s and the other 24 to 53.5 Mc/s. The higher-range coil consists of $5\frac{1}{2}$ turns of No. 18 s.w.g. tinned copper wire $\frac{3}{8}$in diameter and spaced to occupy $\frac{3}{4}$in. Tappings are made to it two turns from either end and the coil is slipped down *inside* an Eddystone Type 763 miniature coil former. Connections are made to the pins as shown in Fig. 4. The second coil is connected in the same way but consists of $8\frac{1}{2}$ turns of No. 26 s.w.g. enamelled copper wire wound on the outside of an Eddystone Type 765 former, which is ribbed and threaded 21 t.p.i. The tappings are taken in this case $2\frac{1}{2}$ turns from one end for the earth tap and $4\frac{1}{2}$ turns from the other (grid) end for the cathode tap.

Calibration is always a problem unless a signal generator or wavemeter is available. However, with the help of a v.h.f. receiver and the shortwave bands of a receiver, and also a lot of patience, acceptable calibration curves can be produced. Great accuracy is not needed in a GDO and for the same reason there is little to be gained by fitting a slow-motion tuning dial. A fairly wide frequency coverage is desirable with any one coil and at the higher frequencies a 2-to-1 frequency range is satisfactory. This is easily achieved with a tuning capacitor of 0 to 50 pF. Nevertheless stray capacitance must be kept at a minimum.

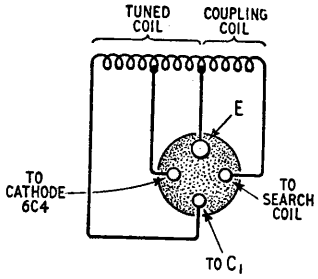
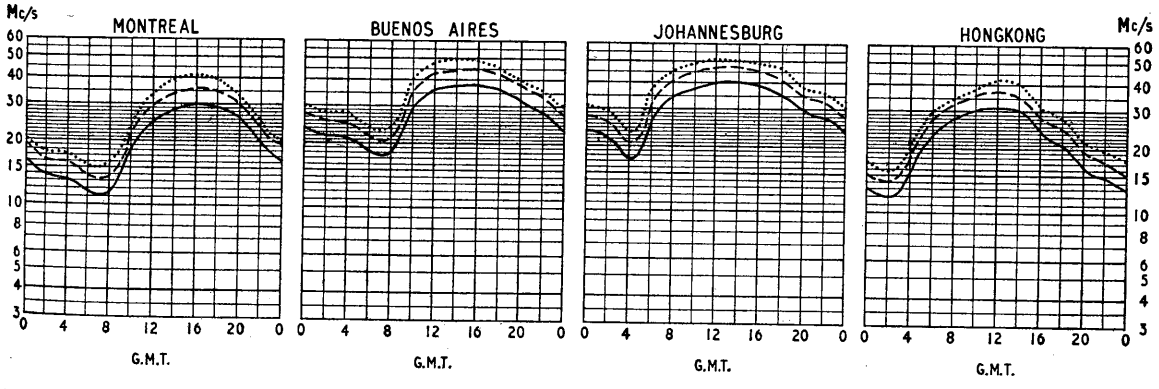


Fig. 4. Connections of the coil L_1 in Fig. 3 to the base pins of the Eddystone former.

The form of construction is unimportant and the GDO can be self-contained with the h.t. unit included and mounted on a handle so that the coil, which must be outside the case, can be poked into the insides of equipments. Another form is to have the power supply separate, and still another is the form shown in the illustrations. The latter has no particular merit except that it enables the leads to the three vital components, the valve, the coil holder and the tuning capacitor to be kept short. The power unit is in the base part. The arrangement shown leaves a little to be desired as the earthy return path of the capacitor is a little longer than is desirable for v.h.f. purposes. It would be better to use a Colpitts circuit if v.h.f. were the only requirement; the reason this circuit was not used in the present case is that a split-stator capacitor of suitable capacitance could not be found. One of 100+100 pF and reasonably small physically was required. This is the main reason why no attempt has been made to reach a higher frequency than 120 Mc/s.

SHORT-WAVE CONDITIONS

Prediction for March



THE full curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during March.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

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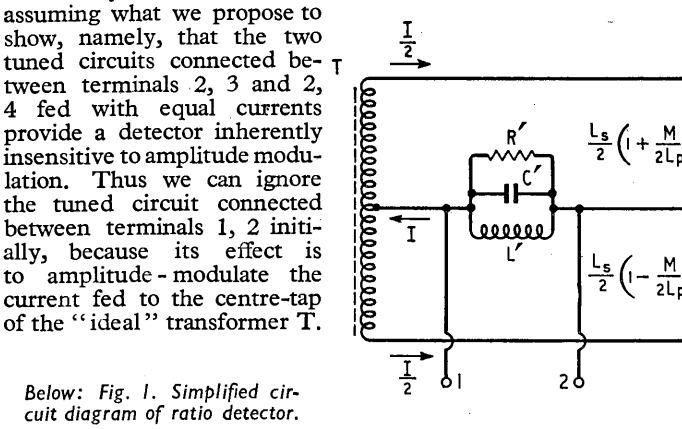
Limiters and Discriminators for F.M. Receivers

By G. G. JOHNSTONE, B.Sc.*

3—The Ratio Detector; Analysis of the "Idealized" Circuit

THE circuit of the conventional ratio detector circuit is essentially similar to that of a Foster-Seeley discriminator, and is shown in simplified form in Fig. 1. It differs from the Foster-Seeley circuit in that one of the diodes is reversed in sense, and in addition a capacitor of the order of 4–20 microfarads is connected in parallel with the load resistors R_L. Because of this capacitor, the voltage across the load resistors cannot change rapidly, and for the purpose of analysis, the two halves of the load circuit can be replaced by two batteries of appropriate voltage. This substitution is justified provided that the rate of variation of the carrier envelope is small compared with the time-constant of the load circuit. We shall return to this qualification later.

In part 1 of this series, an equivalent diagram for the phase-difference transformer shown in Fig. 1 was derived; this equivalent circuit is shown in Fig. 2. The analysis can be considerably simplified by assuming what we propose to show, namely, that the two tuned circuits connected between terminals 2, 3 and 2, 4 fed with equal currents provide a detector inherently insensitive to amplitude modulation. Thus we can ignore the tuned circuit connected between terminals 1, 2 initially, because its effect is to amplitude-modulate the current fed to the centre-tap of the "ideal" transformer T.

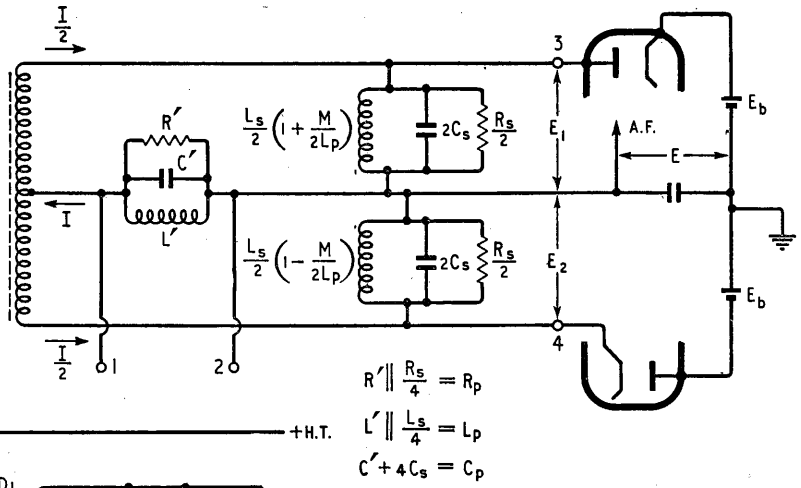


Below: Fig. 1. Simplified circuit diagram of ratio detector.

The latter transformer ensures that the current divides equally between the branches connected to its ends.

We shall first consider two loss-free tuned circuits fed with equal currents with perfect diode detectors, i.e. rectification efficiency is 100 per cent. We shall use the circuit values appropriate to the phase-difference transformer, but the results are equally applicable to an arrangement of two tuned circuits, connected as shown in the equivalent circuit to be analysed (Fig. 3).

"Idealized" Ratio Detector.—Consider first the current flowing in the two diodes. Each diode conducts when the applied voltage reaches its peak value and a short pulse of current flows. It is a property of such a pulse that the d.c. component I_{dc} is equal to half the peak value of the fundamental frequency a.c. component I_{ac} in the equivalent frequency spectrum. These currents can be shown



Above: Fig. 2. Equivalent circuit of Fig. 1.

as loop currents flowing in the paths indicated in Fig. 4. There are currents at harmonic frequencies also, but we shall assume that the loop impedances are very low at these harmonic frequencies, and hence the voltages arising from these components can be ignored. There is only one path for the direct current in both diodes, and hence these currents must be equal. It then follows that the fundamental frequency a.c. components must also be equal in magnitude, although not necessarily in phase.

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The voltages across the tuned circuits are E_1 and E_2 respectively, and the fundamental frequency a.c. component in each diode is in phase with its applied voltage; this is again a property of the components of a short pulse of current. The tuned circuits are loss-free and the currents I_1 and I_2 fed to them are in quadrature with the applied voltages. Thus we may write $(I/2)^2 = I_{ac}^2 + I_1^2$ and $(I/2)^2 = I_{ac}^2 + I_2^2$ where I/2 is the input current to each half of the circuit. From these equations it follows that the magnitude of I_1 is equal to the magnitude of I_2. Thus a basic property of this circuit is that equal currents are fed to the two tuned circuits.

The magnitudes of the voltages E_1 and E_2 will be written as $|E_1|$ and $|E_2|$ and the magnitudes of the currents I_1 and I_2 as $|I_1|$ and $|I_2|$. If the magnitudes of the impedances of the tuned circuits are $|Z_1|$ and $|Z_2|$, then $|E_1| = |I_1| \cdot |Z_1|$ and $|E_2| = |I_2| \cdot |Z_2|$

We have assumed the diode rectification efficiency to be 100 per cent and hence $|E_1| = E_b + E$ and $|E_2| = E_b - E$, where E is the a.f. output voltage. We can thus write

$$E_b + E = |I_1| \cdot |Z_1|$$
$$E_b - E = |I_1| \cdot |Z_2|$$

Adding and substracting these expressions gives

$$2E_b = |I_1| (|Z_1| + |Z_2|)$$
$$2E = |I_1| (|Z_1| - |Z_2|)$$

and dividing gives

$$E = E_b \frac{|Z_1| - |Z_2|}{|Z_1| + |Z_2|}$$

This expression shows that the signal-frequency output voltage is independent of the input current I, i.e. that the circuit is not responsive to amplitude modulation.

To derive the relationship between the output voltage and signal frequency, it is convenient to replace the terms Z_1 and Z_2 by their corresponding admittances Y_1 and Y_2. Writing 1/Y for Z yields

$$E = E_b \frac{|Y_2| - |Y_1|}{|Y_1| + |Y_2|}$$

But

$$Y_1 = 2j\omega C_s + 2/j\omega L_s (1 + M/2L_p)$$

$$Y_2 = 2j\omega C_s + 2/j\omega L_s (1 - M/2L_p)$$

These expressions can be simplified by using Δf_1, and Δf_2 defined as

$$\Delta f_1 = f - f_1$$
$$\Delta f_2 = f - f_2$$

where f_1 and f_2 are the resonance frequencies of the two tuned circuits and f is the signal frequency.

In the neighbourhood of f_1 and f_2,

$$Y_1 = 4jC_s\Delta\omega_1 \quad \text{where} \quad \Delta\omega_1 = 2\pi\Delta f_1$$
$$Y_2 = 4jC_s\Delta\omega_2 \quad \Delta\omega_2 = 2\pi\Delta f_2$$

These expressions can be given in terms of the half bandwidth $\Delta F = (f_1 - f_2)/2 = \Delta\Omega/2\pi$, and the separation $\Delta f = \Delta\omega/2\pi$ of the signal frequency from the centre frequency $f_o = (f_1 + f_2)/2$.

Then

$$\Delta f = \Delta f_1 - \Delta F = \Delta f_2 + \Delta F$$

Thus

$$Y_1 = 4jC_s(\Delta\omega + \Delta\Omega)$$

$$Y_2 = 4jC_s(\Delta\omega - \Delta\Omega)$$

The values of $|Y_1|$ and $|Y_2|$ are plotted in Fig. 5, together with $|Y_1| + |Y_2|$. The resultant characteristic of $E_b (|Y_2| - |Y_1|)/(|Y_1| + |Y_2|)$ is plotted in Fig. 6. This shows that the idealized ratio detector has perfect linearity over the range between the resonance frequencies of the circuits, the output in this range being given by $E = -E_b\Delta f/\Delta F$. In practice, of course it is not possible to realize loss-free tuned circuits and diodes with 100 per cent efficiency. An approach to this condition might be made by applying regeneration to the tuned circuit, but this has not been done to the author's knowledge.

The a.m. rejection properties of a ratio detector must be considered in two parts (a) the degree of

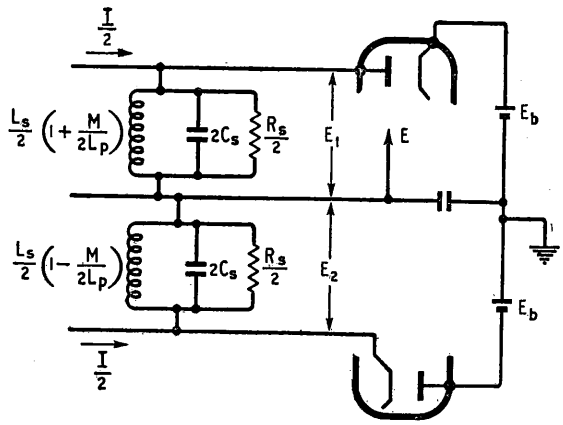

Fig. 3. Simplified circuit for initial analysis.

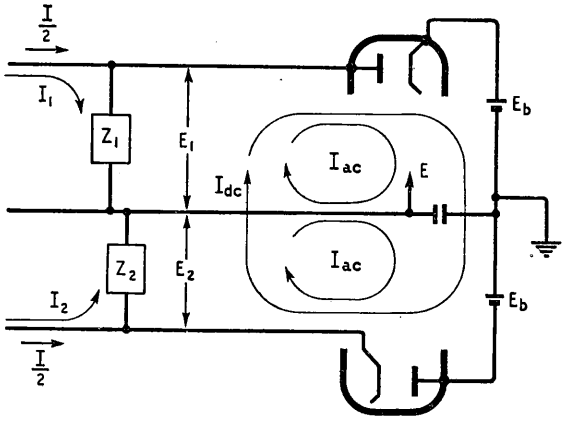

Fig. 4. Showing current paths.

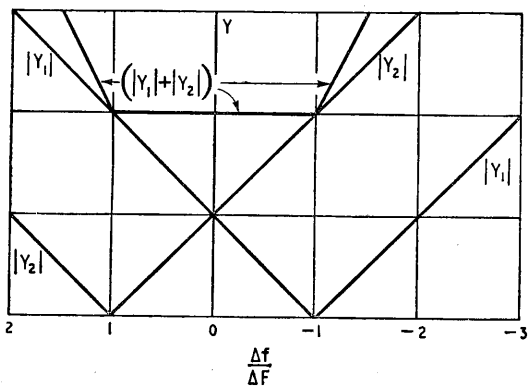

Fig. 5. $|Y_1|$, $|Y_2|$, and $(|Y_1| + |Y_2|)$ plotted against $\Delta f/\Delta F$.

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a.m. rejection, and (b) the working range of signal amplitude over which this rejection is maintained. In the idealized ratio detector considered above, the output was shown to be independent of I, the r.f. input current; thus the detector has no response to a.m. However, it was implicit in the analysis that the input current input was sufficient to maintain current in the diodes at all times, i.e. that the peak voltage across each tuned circuit never fell below that of the battery. The condition where the diodes are cut-off can only occur when the amplitude of the input signal is decreasing, i.e. there is " downward " amplitude modulation. There is no corresponding limit if the signal amplitude increases.

The maximum degree of " downward " amplitude modulation that the detector can handle can be calculated readily. As stated above, the limit occurs when the current through the diodes falls to zero; under these conditions, all the input current (I/2) flows into the tuned circuit. Near the centre frequency, the impedance of each tuned circuit is approximately equal in magnitude to $1/4C_s\Delta\Omega$, and the voltage across each tuned circuit is equal in magnitude to E_b. The resultant current is of magnitude $E_b\ 4C_s\Delta\Omega$. The fundamental frequency a.c. component in the diodes is $2E_b/R_L$ (i.e. twice the d.c. component). These two components are in quadrature and hence

$$(I/2)^2 = E_b^2(16\ C_s^2\Delta\Omega^2 + 4/R^2_L)$$

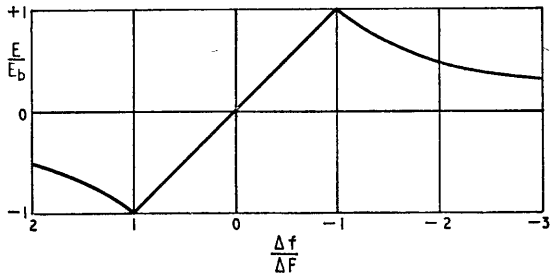

Fig. 6. Audio output plotted against frequency for " idealized " ratio detector.

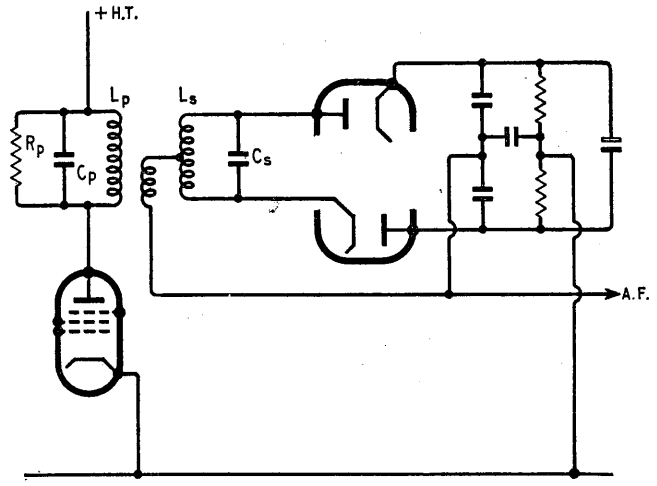

Fig. 7. Ratio detector with tertiary winding closely coupled to primary winding.

When the diode current is cut-off, the input current I′ is given by

$$(I'/2) = E_b(4C_s\Delta\Omega)$$

Thus the maximum amplitude modulation depth that the detector can handle is given by

$$m_{max} = 1 - I'/I$$

$$= 1 - \sqrt{\frac{16\ C_s^2\Delta\Omega^2}{16\ C_s^2\Delta\Omega^2 + 4/R_L^2}}$$

$$= 1 - \sqrt{\frac{4\ R_L^2C_s^2\Delta\Omega^2}{1 + 4R_L^2C_s^2\Delta\Omega^2}}$$

This can be simplified by rearranging the terms, and introducing Q_w, the working Q-value of the tuned circuits, i.e. the Q-value measured under quiescent conditions with the diode circuit damping present. The damping due to the presence of the diode load resistor is equivalent to a resistance of $R_L/2$ in parallel with each circuit, and thus the working Q-value may be defined as

$$Q_w = \frac{R_L}{2} \cdot \frac{1}{(L\omega_o/2)} = R_L\omega_oC_s$$

Then

$$m_{max} = 1 - \sqrt{\frac{(2Q_w\Delta F/f_o)^2}{1 + (2\ Q_w\Delta F/f_o)^2}}$$

If m is large, the expression simplifies to

$$m_{max} = 1 - 2\ Q_w(\Delta F/f_o)$$

From the expressions derived above, the conditions that the detector should have good " downward " a.m. rejection properties are apparent. These are that Q_w and ΔF should be small, and f_o should be large. In general the half-bandwidth ΔF cannot be decreased indefinitely, or distortion results. Similarly f_o is fixed by other considerations. Hence Q_w is the only independent variable. If, for example, $\Delta F = 75$ kc/s, and $f_o = 10.7$ Mc/s and the detector is required to handle a.m. to a modulation depth of 0.9, then

$$0.9 = 1 - 2Q_w(75/10700)$$

$$Q_w = 7.2 \text{ approximately.}$$

In terms of circuit values, this requires that the load resistor be 1,150 ohms approximately, if the tuning capacitance of the phase-difference transformer is 50 pF.

The above calculations show clearly that the conditions for good "downward" modulation handling capabilities require a narrow bandwidth; thus if a wide-band detector is required, it must be preceded by a limiter stage, since its inherent ability to deal with a.m. is seriously impaired by its wide bandwidth. This situation cannot be remedied by reducing Q_w, since in a practical circuit there is a limit to this imposed by considerations of diode efficiency.

To complete the investigation of the " idealized " ratio detector we will deduce the sensitivity of the circuit. It was shown above that the a.f. output voltage is proportional to E_b and, other parameters being fixed, it is desirable that E_b should be as large as possible. The usual way of achieving this object is to employ a tertiary winding closely coupled to the primary circuit as shown in Fig. 7. This steps up the input current and reduces the impedance level. The use of a tapped primary circuit

(continued on page 127)

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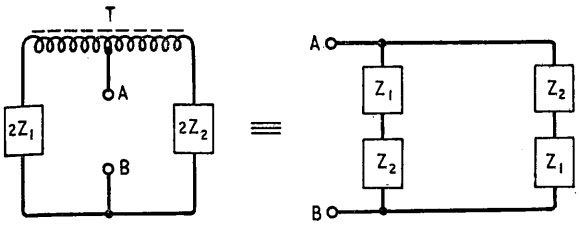

Fig. 8. Equivalent circuit to determine impedance measured between terminals A and B.

was discussed in part 2 of this article, where it was shown that the primary circuit proper must be replaced before the analysis is commenced by another tuned circuit, whose parameters are given below. The fraction a represents the fraction of the primary circuit voltage tapped off by the tertiary winding. $L_p' = a^2L_p$; $C_p' = C_p/a^2$; $R_p' = a^2R_p$; $I' = I/a$; $M' = aM$.

To determine the value of I we must calculate the input impedance presented at the centre tap of the transformer T in the equivalent diagram of Fig. 2. This can best be done by utilizing one of the intermediate stages in the derivation of the equivalent circuit, which was given in part 1; this is shown in Fig. 8. At the centre frequency, the input impedance R_{in} is purely resistive and can be shown to be

$$R_{in} = (R_L/4)/\{1 + (2Q_w\Delta F/f_o)^2\}$$

We shall assume that the signal is close to the centre frequency. This is the resonance frequency of the circuit connected between terminals 1 and 2 and hence the reactive component of its impedance can be ignored. Since $R_s/4$ is infinite, the equivalent circuit reduces to that of Fig. 9.

The proportion of the input current I_{in} fed to the centre-tap of the transformer T is thus given by

$$I = \frac{I_{in}}{a} \cdot \frac{a^2R_p}{R_{in} + a^2R_p} = I_{in} \frac{aR_p}{R_{in} + a^2R_p}$$

This reaches a maximum value when

$$a^2 = \frac{R_{in}}{R_p} = \frac{1}{R_p} \frac{R_L}{4\{1+(2Q_w\Delta F/f_o)^2\}}$$

At this value of a

$$I = I_{in}/2a$$

If we assume that $(2Q_w\Delta F/f_o)$ is small, as required for good "downward" a.m. handling capacity, the expression for a simplifies to

$$a^2 = R_L/4R_P$$

We have shown earlier that the output voltage $E = -E_b\Delta f/\Delta F$. The value of E_b can be determined simply when the value of a is chosen for power matching as described above, when $I = I_{in}/2a$. The power delivered to the centre-tap of the transformer T is $P = \frac{1}{2}(I_{in}/2a)^2R_{in} = \frac{1}{2}(I_{in}/2a)^2a^2R_p = \frac{1}{8}I_{in}^2R_p$.

The network has no losses, and hence this power is delivered entirely to the load circuit. This power is given by

$$P = 2E_b^2/R_L$$

whence

$$E_b = \tfrac{1}{4}I_{in}\sqrt{R_pR_L}$$

Thus for maximum output for a given value of Δf, R_p and R_L should be large, and ΔF small. But R_L is directly proportional to Q_w, and it was shown

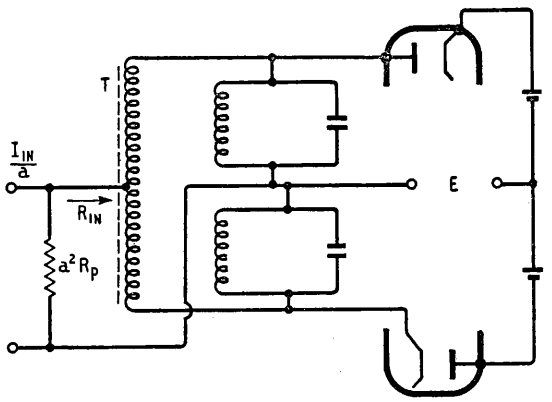

Fig. 9. Circuit for determining division of input current I_{in}/a.

earlier that for good "downward" a.m. handling capacity, Q_w should be small. This is diametrically opposed to the condition for maximum sensitivity as shown by the expression above, which requires R_L large. The expression shows also that a wide-band discriminator can only be secured at the expense of sensitivity, and as shown earlier, at the expense also of the "downward" a.m. handling capacity.

(To be continued)

New "Wireless World" Books

Foundations of Wireless by M. G. Scroggie, B.Sc., M.I.E.E. This well-known book on the basic theory of radio transmission and reception has now reached its sixth edition. An introductory section on the use of algebraic symbols, graphs and circuit diagrams clarifies the small amount of mathematics that is included. The fundamental laws of electricity and the theory of valves are discussed and no previous technical knowledge on the part of the reader is assumed. Subjects which are treated include television, radar and transmission lines. There is a new chapter on semi-conductors, which, with other additions, keeps this book right up-to-date. The book has 349 pages and costs 12s 6d (postage 1s).

Television Receiving Equipment by W. T. Cocking, M.I.E.E. The advent of Band III and other new developments in television have necessitated almost complete rewriting, and the addition of 169 pages of new material to this, the fourth, edition of a book which has become one of the classics of the subject. Topics discussed in fuller detail in this edition include magnetic deflection (greatly expanded) and the increasing problems of interference. The comprehensive treatment covers both theoretical and practical aspects of the subject. Modifications necessary to deal with systems other than the British are also discussed. The book has 454 pages and costs 30s (postage 1s 6d).

Television Engineering, Vol. III by S. W. Amos and D. C. Birkinshaw. This volume in the series of B.B.C. Engineering Training Manuals covers the properties, generation and application of the various waveforms used in television (sinusoidal, rectangular, sawtooth and parabolic). The treatment is mainly devoted to the generation of these waveforms, and being more fundamental and descriptive, is less mathematical than the two previous volumes. Vol. IV (in preparation) dealing with the various circuit techniques, will complete the series. The book has 226 pages and costs 30s (postage 11d).

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Electroluminescence

A NEW "COLD LIGHT" AND ITS APPLICATION TO ELECTRONICS

By D. W. G. BALLENTYNE*, B.Sc.

PHOSPHORS have been used extensively in the electronic industry for television and radar displays for many years. A phosphor is a substance which absorbs quanta of energy from an exciting source and converts part of this energy into visible light. The primary excitant may be either a photon (e.g., ultra violet light) or a charged material particle (e.g., an electron). The lighting industry is concerned with the manufacture of phosphors of the first type, photoluminescent phosphors, which have a strong absorption for one of the lines of the mercury arc spectrum, whilst the electronic industry is interested in phosphors which are excited by an electron beam, i.e., cathodoluminescent phosphors. In general, phosphors of both these classes are inorganic crystalline solids consisting of a "host" crystal which, of course, must be transparent and which has incorporated in it by heat a small quantity of another substance, the activator.

It is intended to discuss in this article a relatively newly investigated type of luminescence produced by the application of an alternating field. As long ago as 1920 Gudden and Pohl noticed that the decay of an ultra violet excited zinc sulphide phosphor activated with copper was affected by the application of a steady field, and during the intervening years much work has been done on this phenomenon, which has become known as electrophotoluminescence. In 1938 G. Destriau noticed that sustained emission of light could be obtained from a previously unexcited phosphor by the application of an alternating field to the phosphor suspended in the dielectric of a capacitor. This phenomenon is known as electroluminescence. This work was reported fully in a series of articles in 1947[1]. At the time, however, the efficiency of the phosphors was so low and the electroluminescent device so cumbersome as to be of no practical importance.

In 1950, E. C. Payne *et al*[2] indicated how electroluminescence could be put to practical use and, since this time, an increasing volume of work has gone into the production of more efficient phosphors and their incorporation in panels for use as lighting sources. Unfortunately, however, at the voltages and frequencies available domestically the light output is poor and electroluminescent panels are of use only as large-area low-level light sources. The same limitations in voltage and frequency do not exist in electronic equipment, where the brightness of the emission is limited only by the breakdown voltage of the dielectric in the electroluminescent capacitor—and thus it may be that this phenomenon will be found more useful in flat displays or light amplifiers for television and radar.

A large number of different inorganic compounds have been used as the host crystals for luminescent materials but only one of these classes has been found to be efficient when excited by an alternating voltage. All electroluminescent phosphors used industrially are zinc or cadmium sulphides or selenides activated with copper. The original electroluminescent phosphors prepared by Destriau were mixed crystals of zinc oxide-zinc sulphide containing copper but, as has already been pointed out, the light output of these was feeble. Phosphors containing copper normally give a greenish light, but other colours—notably yellow, blue and orange—can be obtained by varying the amount of copper and adding very small quantities of other substances such as aluminium, manganese and lead. It is obvious that an additive white may be obtained by mixing together a blue, green and orange phosphor. A better rendering of white could be obtained if an efficient red phosphor could be prepared, but at the moment the red phosphors, usually containing zinc selenide, are not efficient.

The electroluminescent effect was first demonstrated by Destriau in a cell as shown in Fig. 1. A suspension of the phosphor in castor oil placed upon a copper block was covered with a mica sheet. The upper surface of the mica sheet was wetted with glycerined salt solution and the field was applied between this electrode and the copper. This device could not be of practical importance.

The practical light source generally used is shown in Fig. 2. The phosphor suspended in a dielectric is applied to a sheet of conducting glass, another opaque conducting layer being applied to the back of this film. Conducting glass is easily prepared by the application of stannic chloride vapour to the glass sheet, heated to a temperature just below the softening point of the glass when atoms of tin diffuse

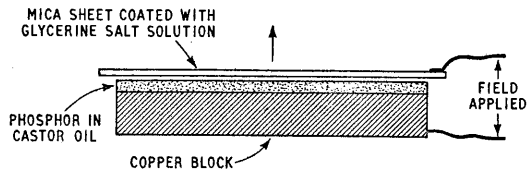

Fig. 1. Destriau's original electroluminescent cell.

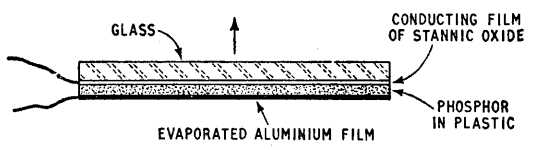

Fig. 2. A conventional electroluminescent light source.

* Marconi's Wireless Telegraph Company. This article is based on a paper which appeared in *The Marconi Review*, 19, No. 123 (4th Quarter 1956).

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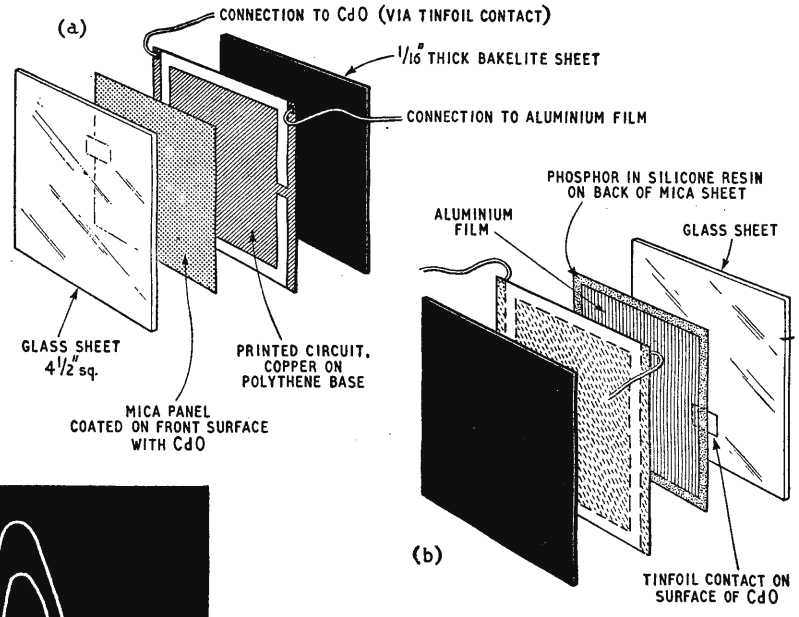
into the surface and form a semi-conducting layer. The conducting back electrode can be either an evaporated film of aluminium, or a sprayed layer of silver or graphite. The last-mentioned two substances have the disadvantage that they absorb part of the light, while, of course, an aluminium layer reflects the light and so produces an apparent increase in brightness.

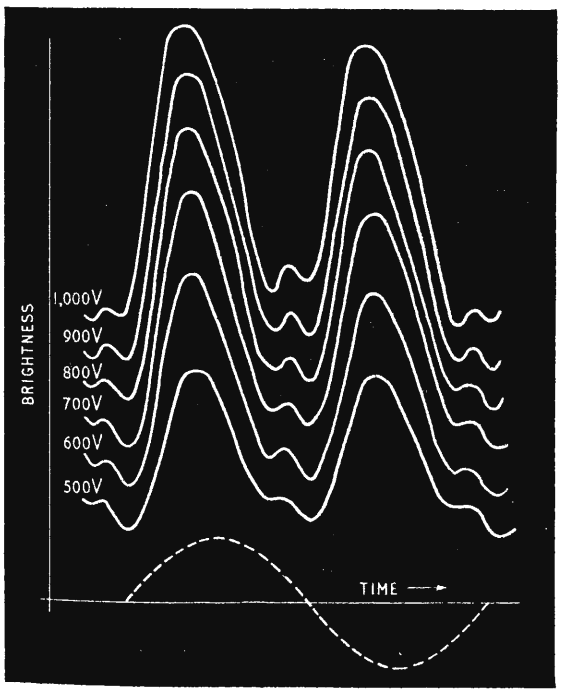
The continued life of such panels depends upon the dielectric strength of the plastic layer and although such panels are easily prepared for use at low voltages[3] we feel that a more robust panel may be necessary for continued operation at higher voltages. The design of the panel used by us is shown in Fig. 3 (*a*) and (*b*) in an exploded view. The phosphor suspended in a silicone resin is applied to one side of a mica sheet, and an aluminium electrode is evaporated on to this film after it has been cured. A conducting layer is then applied to the other side of the sheet. A number of substances have been used for this layer. The best film for the purpose appears to be a sputtered layer of cadmium oxide. This layer is susceptible to fingermarking and should be protected by a film of silicone lacquer. Contact is made to both the front and back electrodes by means of a printed circuit on a flexible base. The whole cell is clamped together and beeswax is poured between the Bakelite backing sheet and the glass. Panels constructed in this fashion can be excited by voltages of up to 1,500 but at 230 volts and 50 c/s are of the same order of efficiency as commercially available panels.

It was shown by Destriau that the application of an alternating voltage to an electroluminescent panel produced a light output whose amplitude varied with time. The exact nature of the variation depends to some extent upon the phosphor. Thus Fig. 4 shows the variation of the amplitude of the brightness with time for various voltages for a zinc sulphide phosphor activated with copper. In this case

Right. Fig. 3. Exploded views, (a) front and (b) back, of an electroluminescent panel constructed in the author's laboratory. In (b) there is a tinfoil connection between the printed circuit contact and the cadmium oxide surface of the mica panel.


(a)
CONNECTION TO CdO (VIA TINFOIL CONTACT)
1/16" THICK BAKELITE SHEET
CONNECTION TO ALUMINIUM FILM
GLASS SHEET 4 1/2" sq.
PRINTED CIRCUIT, COPPER ON POLYTHENE BASE
MICA PANEL COATED ON FRONT SURFACE WITH CdO
PHOSPHOR IN SILICONE RESIN ON BACK OF MICA SHEET
ALUMINIUM FILM
GLASS SHEET
(b)
TINFOIL CONTACT ON SURFACE OF CdO

Below. Fig. 4. Brightness waves for a zinc sulphide phosphor actuated with copper and aluminium. The relative phase of the exciting voltage is shown by the dotted sine wave.



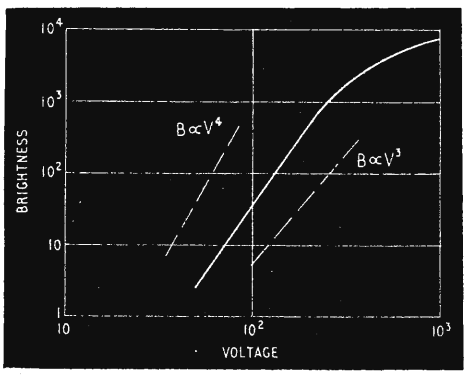


Fig. 5. Variation of mean brightness of an electroluminescent panel with applied voltage.

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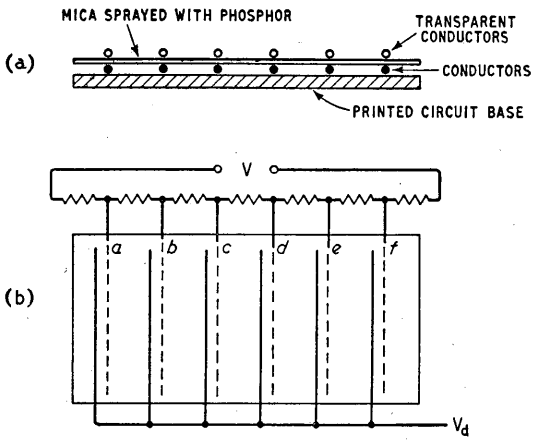


it can be seen that there are two primary brightness maxima and two so-called secondary maxima for each cycle of voltage.

For all practical purposes the variation of brightness with mean applied voltage can be expressed by the relation

$$B = a\,V^n \quad .. \quad .. \quad .. \quad (1)$$

where n lies between 3 and 4 (Fig. 5). It is obvious that this relation is true only at low voltages and, in fact, the variation of voltage with brightness more exactly follows a law of the form

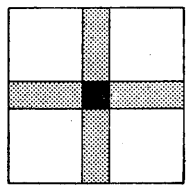
$$B = a\,V^n \exp(-b/V) \quad .. \quad (2)$$

where a, b and n are constants and n has a value between 1 and 3, depending upon the phosphor, but which is generally equal to approximately 2.

Although the brightness is considered above as a function of voltage it must not be forgotten that electroluminescence is a field effect and the effective quantity is not voltage but voltage/distance. As the panels are of constant thickness the use of voltage rather than field will not affect the theoretical considerations except to the extent of introducing a numerical proportionality constant.

The marked dependence of brightness on voltage is of great importance for, as the voltage applied to a panel need not be limited in an electronic device, a great improvement in the brightness of the panels can easily be obtained. The ultimate limit to the applied voltage will be set, as pointed out above, by the strength of the dielectric layer.

The frequency of the applied alternating voltage also affects the brightness of the panel, and according to Destriau the way in which it does so varies from phosphor to phosphor. In general, at low frequencies and for singly activated phosphors most workers agree that the effect is linear. At higher frequencies some saturation occurs and even in some extreme cases a maximum is observed. Multiple activated phosphors behave in a different fashion, for the intensity of light due to the emission band of each activator may vary differently with frequency and thus the colour of the phosphor may change as the frequency increases. Hence a zinc sulphide phosphor activated with copper and manganese is orange at low frequencies due to the manganese emission and green at high frequencies when the colour is determined by the copper emission. This dual dependence on frequency leads, in general, to a variation of brightness with frequency which is not linear[4].



(c)

Fig. 6. A black-spot electroluminescent display system: (a) edge view, (b) front view showing electrical connections, (c) a black spot produced by two non-emitting strips at right angles.

The efficiency of an electroluminescent panel is not affected appreciably by increasing frequency. At low frequencies there is a slight increase in efficiency while at higher frequencies the efficiency decreases slightly, probably due to the impedance of the conducting glass film. The variation of electroluminescence efficiency with voltage is more difficult to understand. At low voltages it increases roughly as a third power of the voltage but it reaches a maximum at voltages of the order of 500 volts/mil and then decreases. This effect is most noticeable at low frequencies.

Many attempts have been made to devise an equivalent circuit which will explain the various properties of these phosphors. Some of these circuits[5] are most complicated. Probably the simplest circuit which will represent the behaviour of an electroluminescent panel is a resistor in series with a capacitor which has another resistor in parallel with it. In a previous paper[6] it has been demonstrated that if the parallel resistor is assumed to be voltage dependent, a relationship between brightness and voltage of approximately the correct form can be deduced, provided the assumption is made that the brightness is proportional to the power available for dissipation. A calculation of the efficiency to be expected under these conditions leads to the result that at low frequencies the efficiency should approach unity and it should decrease as the voltage increases. The reason for the experimentally observed initial increase in efficiency is not clear.

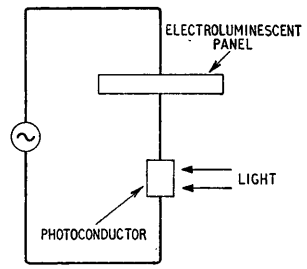


Fig. 7. An elementary light amplifier.

Destriau's original conception of a capacitive electroluminescent light source has not been advanced significantly since the announcement of a practical panel in 1950[2]. In general, until the brightness of the panels is increased by an order of magnitude when excited at 230V and 50 c/s they will not constitute a serious threat to the more conventional types of light source. There are, however, a number of uses to which panels have been put which depend upon two unique properties of these lights—their thinness and the fact that no heat is dissipated during operation. Hence electroluminescence is suitable for low-level lighting where space is restricted, for lighting in silhouette and for luminous signs and dials.

A specialized and important application of this phenomenon is in photographic processing. As is well known, only non-actinic lights can be tolerated

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in the darkroom and, conventionally, such lighting is provided by the light transmitted by a suitable filter placed in front of a light box. Because white light must not be allowed to escape from the box, cooling presents a difficult problem and inefficient cooling results in a rapid deterioration of the filter. An electroluminescent panel is a considerable improvement on the conventional light box.

Illuminated signs in cinemas and theatres are another application of this type of light, for exit signs, indicating obstructions such as the risers of a staircase, and in general for lighting the gangways.

Electroluminescence offers an improved method of lighting instrument dials, as the lettering on the dial itself is illuminated and thus distortion and errors in reading caused by parallax are reduced to a minimum. Uses of this kind are increasing in the aircraft industry where a 400-c/s supply is available in the aircraft with its attendant increase in brightness of the panel. A comprehensive review of these uses is given by Bowtell and Bate[3].

Television Display

The most obvious use for a light source which can be made to emit by the application of a field is for the display of information and here one naturally thinks of television. Display of information can be accomplished in two ways, either by applying a voltage sufficient to make the phosphor luminesce at a point (x, y) or to apply this voltage to the whole panel and to remove it at the point (x, y) by the application of a biasing voltage.

The first method, which requires that the electrodes of the panel shall consist of two sets of orthogonal strips, is in essence the easier way but the problems of commutation of the strips is formidable. Mechanical commutation, although possible, is obviously so cumbersome as to be an unattractive solution of the problem. A line of investigation worthy of study would appear to be the use of a scanned cathodoluminescent phosphor in conjunction with a set of photoconductor elements, one element actuating each strip in the grid. Such a method waits, however, on the preparation of a photoconductor with a rapid decay, as the persistence of the image on the display screen will be determined by the rate of decay of the photoconductor or, if this is very fast, by the decay time of the cathodoluminescent phosphor. Such a decay is essential when using electroluminescence to display information, as electroluminescent phosphors themselves have an undetectable persistence.

A device of the other type has been described[7]. Fig. 6(*a*) and (*b*) show one-half of such a device. It consists of a printed circuit on which a set of conductors is laid down, a piece of mica on which the phosphor has been sprayed, and another set of transparent conductors evaporated on to the other surface of the mica sheet. The voltage at *a, b, c,* etc., is determined by the resistors and varies from V_a to V_f, whilst the voltage applied to the continuous electrode can be set between V_a and V_f but is always 180° out of phase with the voltage on the other strips. In the diagram it has been set at V_d. The voltage at *d* is zero, while a residual voltage appears on each of the other strips and light will be emitted from all strips except *d*. If it is supposed that another such cell is placed in contact with the first cell but with the conductors orthogonally disposed to those on the first cell, a

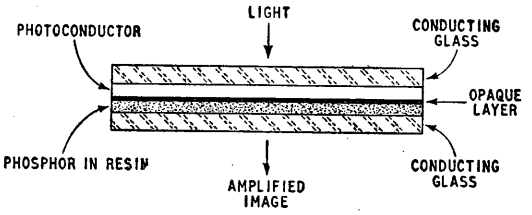

Fig. 8. Conventional construction of a light amplifier.

black spot will appear as shown in the diagram at (*c*).

Experiment has shown that such a device will only become feasible with phosphors of greatly increased efficiency which will give an appreciable amount of light at low fields, otherwise the resolution of the device becomes poor. An increase in resolution is limited by the dielectric strength of the material, for a voltage approaching $V \times f$ is applied to strip *a* when strip *f* is extinguished, and for a device with a reasonable number of strips using phosphors available to-day such a voltage is prohibited by the dielectric strength of the panel.

The consideration of an electroluminescent panel in series with a photoconductor leads to many new devices of great importance.

Suppose that a source of light is focused on to the photoconductor in Fig. 7; the impedance of the circuit will decrease, current will flow and light will be emitted. The intensity of the emitted light will be independent of the intensity of the exciting light. The construction of a light amplifier now becomes possible. A number of such devices have been described and amplifications of between five and 24 have been claimed. In essence such devices are simple to construct and a light amplifying panel such as that shown in Fig. 8 should produce an image of a projected picture. The amplifier consists of a sheet of conducting glass on to which a phosphor is applied, suspended in a resin. An opaque layer is applied to the baked resin and then a thick layer (20 mils) of a photoconducting cadmium sulphide is laid down. Finally a transparent backing electrode, usually another sheet of conducting glass, is applied to the back of the device. Light incident on the photoconductor will reduce its resistance and therefore the voltage applied to the phosphor layer will be determined by the intensity of the light. Under these conditions a picture projected on to the photoconductor will be reproduced on the electroluminescent panel and, as the brightness of the emitted light is independent of the exciting light and is only dependent on the exciting voltage, light amplification may be achieved. In fact, of course, the resolution of such a simple device is poor but many more complicated systems have been devised to overcome this defect and some of them are reviewed by B. Kazan and F. H. Nichol.[8] A promising field of application of the light amplifier is as an image converter to convert ultra violet or infra red radiation into visible radiation.

Binary Storage Devices

F. E. Loebner[9] has discussed the use of electroluminescent panels in series with crystalline cadmium sulphide photoconductors in various devices to which the generic name "opto-electronic transducers" has been given. The physical dimensions of these devices

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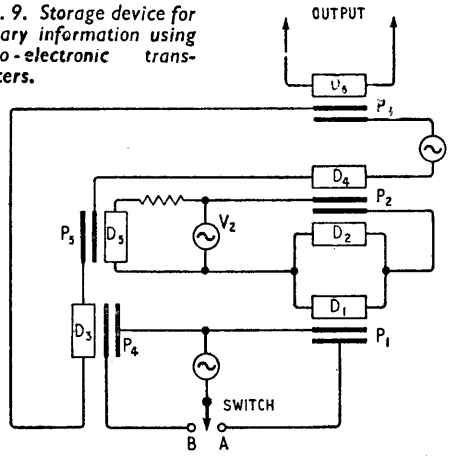

Fig. 9. Storage device for binary information using opto-electronic transducers.

are small. They consist of an electroluminescent panel ($\frac{1}{4}$in×$\frac{1}{4}$in) in contact with a cadmium sulphide crystal to which electrical contact is made by a cats-whisker. There are many uses for devices of this type—for instance, in the construction of storage cells and shift registers for computers.

Fig. 9 shows diagrammatically an elementary storage cell. The information is supplied in the form of a pulse by throwing the switch to A. This causes panel P_1 to light for a short period of time. Panel P_1 illuminates detector D_1 and causes its resistance to decrease and panel P_2 to light. The illumination from P_2 reduces the resistance of D_2 and thus, although the resistance of D_1 returns to its static value, panel P_2 remains on. Thus the information is stored. If the switch is thrown to B panel P_4 becomes illuminated, causing the resistance of D_3 to fall. The system is so arranged that a fall in the resistance of D_3 or D_4 on its own is not sufficient to light the panel P_3. Thus if no information is stored in P_2 the connection of the switch arm to B will not produce a light pulse at P_3 but if P_2 is on, P_3 will light up and a voltage will appear at the output. Simultaneously P_5 will light up, reducing the resistance of D_5 to a small value and shorting the voltage source V_2. Panel P_2 is now extinguished and the whole system returns to an unlit condition ready to receive further information.

From a consideration of this elementary circuit the endless possibilities of devices of this type are apparent. For most uses, however, it is necessary that the decay time of the detector elements should be very rapid and at present this cannot be achieved practically.

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Nine-Kilowatt Audio System

EVEN the most rabid high-power audio enthusiast should be satisfied with the power available from a system described recently.* This uses three 3-kW amplifiers to drive an array of 240 loudspeakers.

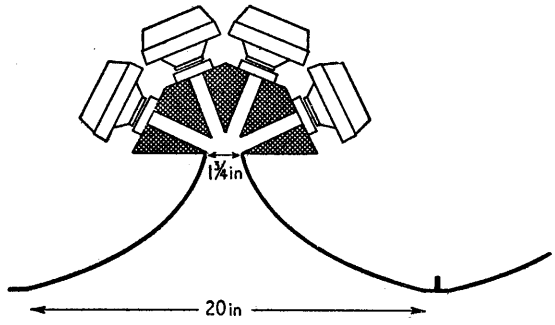
The system is installed in a B26 aeroplane for transmitting speech to the ground. Within a quarter of a mile of the projected flight path it provides what is referred to as "marginal" intelligibility for a period of fifteen seconds when the aircraft is flying at 150 m.p.h. at a height of 6,000ft.

The loudspeakers are horn loaded, three separate twin horns being used to decrease the distortion produced by excessive air pressures, and also to fit into the space available. A section of one such horn with the beginning of its corresponding twin is shown in the accompanying drawing. There are ten loudspeakers in each of the four rows; and the throat from each loudspeaker is exponentially flared in a direction at right angles to the cross-section plane.

The horns cut off at 400 c/s and from here to the designed upper frequency limit of 4 kc/s response is flat within ±5 dB. At the full input of 37 watts to each speaker their operating life is several hours. They are connected in a series-parallel arrangement to give an impedance of eight ohms. In this arrangement some of the voice coils have high instantaneous audio voltages on them (≈ 150 volts), and there was a tendency for these coils to arc-over to the earthed magnet. This was avoided by initial testing and selection of speakers.

Response of the special lightweight amplifier is flat from 400-4,000 c/s within ±0.1 dB, and the distortion at full output is about 10%.

As the loudspeakers are rather directional, an increase in the intelligibility period to thirty seconds is obtained by partially rotating them to follow the objective of each



Cross-section of half-twin horn with drivers.

transmission. The directivity is somewhat irregular at high frequencies owing to the use of twin horns. This irregularity could be avoided by using the same arrangement of throats and driver units combined to feed a single horn which has been developed. Although this single horn has a larger throat area, the rate of flare is decreased, since it has the same length; and the distortion arising in the horn is unfortunately increased.

The input system contains a high-pass filter to protect the loudspeakers, and a symmetrical peak clipper to protect the amplifiers. In the conditions of use high-frequency air losses are considerable. The speech is therefore high-frequency pre-emphasized to give an equal output at all frequencies. This only partially compensates for the air losses; but any further pre-emphasis would decrease the available power at the lower frequencies, and these are the most useful for speech reproduction.

* D. W. Martin *et al.* "An Experimental 9,000-watt Airborne Sound System." *I.R.E. Trans. Audio*, Nov.-Dec. 1956.

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Series or Parallel?

In Which Negative Resistance Again Raises Its Head

By "CATHODE RAY"

QUITE a long time ago* I offered a small collection of very simple circuit problems of the kind that are apt to provoke considerable controversy. The first of them, Fig. 1, is repeated here. I was reminded of it by the negative resistance problem discussed in the last two issues, which arose out of Thomas Roddam's article of the same name more than two years earlier (July 1954, to be exact). Mr. Roddam started his article with exactly the same Fig. 1 as I did in 1946 (and here now), but he added considerable spice to the question by supposing R_1 to be negative.

Quoting me, he agreed that the parallel combination as a whole is negative if the *smaller* of the two resistances is negative. The values we tried were $R_1 = -15\,k\Omega$ and $R_2 = 20\,k\Omega$; then the resistance of the two in parallel, by the usual formula, $R_1R_2/(R_1 + R_2)$, is $-60k\Omega$. So the combination would be unstable. But he also pointed out what I did not on that particular occasion, that the two resistances in Fig. 1 can equally well be regarded as being in series, in which case the resistance of the whole combination is $R_1 + R_2 = -15 + 20 = 5\,k\Omega$, which, being positive, means that the thing is stable. So it is both stable and unstable at the same time!

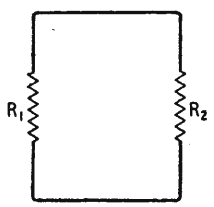

Fig. 1. Are R_1 and R_2 in series or in parallel?

Just to make this absurdity even more convincing, let us follow up this particular example. The value of any resistance, of course, is the ratio of voltage across it to current flowing through it. This applies whether the resistance is positive or negative, the sign being decided by which way the current flows. Resistance is regarded as positive when it absorbs power, which it does when the current flows from high to low potential within it; that is to say, from the positive to the negative end. So when we find a part of a circuit where current is coming out from the positive terminal instead of going in, so that it can be used as a source of power, we can regard it as a negative resistance.

In Fig. 2 let us suppose that 1 mA is coming out of the positive end of R_1. The voltage across it must therefore be 15 V. So it is supplying $15 \times 1 = 15$ mW of power. That much is the same in both (a) and (b). But how do we make the ratio of voltage to current right for R_2? The direction is right, of course, for what comes out of the positive end of R_1 goes into the positive end of R_2. If the whole 1 mA went in, the voltage across R_2 would be 20, whereas it must actually be 15. We can make things balance by bleeding off $\frac{1}{4}$ mA, as at (a); the negative resistance is then supplying not only the $11\frac{1}{4}$ mW represented by the $\frac{3}{4}$ mA going into R_2 down a 15-V slope, but can spare $3\frac{3}{4}$ mW wherever the $\frac{1}{4}$ mA goes. The resistance of the combination is therefore negative, as we calculated at the start.

An alternative method is to supply the extra 5 V needed to drive the full 1 mA through R_2, as at (b). Here, the 15 mW provided by R_1 is insufficient for the 20 mW absorbed by R_2, and needs a supplementary 5 mW from the voltage generator—the 5-V battery.

In one case the system has power enough and to spare; in the other (which is really the same, for the component values are identical!) it has to be subsidized. The question is, once more, how the circuit decides whether it is a power exporting or importing unit. On paper it can be either, as Fig. 2 shows. What decides whether its net resistance is $R_1 + R_2$ or $R_1R_2/(R_1 + R_2)$; positive or negative?

This paradox is just another form of the problem of how two voltage/current graphs crossing one another at an angle—one representing a positive resistance and the other a negative—can together represent either a stable or unstable condition. Readers of the last issue will, I hope, be clear that the key to the question is that negative resistance comes in two kinds. With ordinary positive resistance, in which voltage and current are in direct proportion, either voltage or current can be the cause and the other its effect. But negative resistance means that an increase in one corresponds to a decrease in the other. Such conduct being, as it were, "agin' Nature," does not result from normal properties of materials as in resistors, but from some kind of secondary effect, which introduces a one-way causative direction not found in ordinary resistance. Until we grasped this, our interpretation of V/I graphs went badly astray, for they can be the opposite of true if cause and effect are assumed to be interchangeable for negative slopes as well as

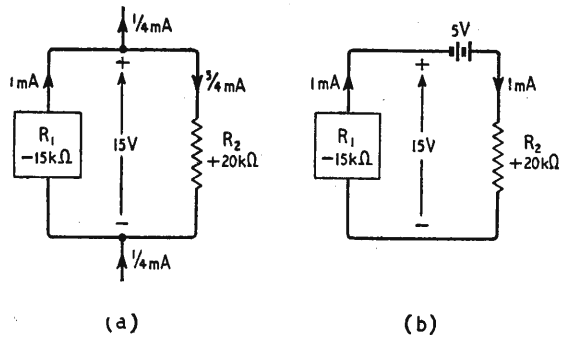

Fig. 2. Although the values for R_1 and R_2—the only circuit components—are the same in both diagrams, and the voltages and currents are correct for both, (a) can be seen to export power, while (b) has to import it from a 5-V battery. How can this be?

*"Conventions and Viewpoints," *Wireless World*, September 1946. (Chap. 30 in *Second Thoughts on Radio Theory*.)

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positive. The slope itself doesn't show which; one has to look to see which way the slope bends back to positive resistance at its ends.

Let us try the same key on Fig. 2. When graphical treatment let us down, we discovered the nature of its limitations by examining typical negative-resistance devices—dynatron and point-contact transistor. Both of these probably being unfamiliar in practice to most readers, it may be a good idea this time to take a simple valve circuit which can easily be arranged to provide both kinds of negative resistance (Fig. 3). It is in any case a particularly useful and versatile circuit, which everyone ought to know*. The components required are few and common: almost any twin triode, connected as a resistance-coupled stage and cathode follower.

Disregarding very low and high frequencies, at which C_1 and stray shunt capacitances respectively cause phase shifts, we find that the impedances between terminals S_1 and S_2 and between P_1 and P_2 are both negative resistances. The circuit can be made into an oscillator by connecting a simple LC tuned circuit between either pair of terminals. But if it is connected to P_1 P_2 the other pair must be joined together and L and C must be in parallel (rejector circuit), whereas if connected to S_1 S_2 they must be in series (acceptor circuit) and P_1 P_2 left open-circuited. As a negative-resistance device, Fig. 3 resembles the dynatron between P_1 P_2 and the transistor between S_1 S_2.

Technician's Viewpoint

If we pause to ponder this distinction, the circuit technician will no doubt point out that P_1 P_2 is obviously a high-impedance part of the circuit—R_3 is usually of the megohm order, to have just enough conductance to stabilize the potential of the grid, where current is practically zero—and a rejector circuit provides the high impedance needed to prevent loss of amplification; whereas the reverse applies at S_1 S_2, where an acceptor provides the low impedance needed to feed back enough of the said amplification to cause oscillation. Since we would appear to him very dim-witted to be having any hesitation at all about the series and parallel natures of the two connections, he might (if a kind chap, tolerant of others' mental handicaps) draw Fig. 4 for us, showing with almost painful simplicity essentially the same system as Fig. 3—an amplifier with part of the output fed back from across a potential divider. Taking care to use easy words, he would point out that oscillation is promoted by *high* resistance between P_1 P_2, in *parallel* with the amplifier-feedback loop, in order to pass on an operating *voltage*, and that the same tendency results from *low* resistance between S_1 S_2, in *series* with the loop, in order to pass on an operating *current*.

That is all very obviously true, but when in the early days I enquired about the essential difference between a voltmeter and an ammeter, and I was informed that a voltmeter has many turns of fine wire, giving it a high resistance, whereas an ammeter is wound with few turns of thick wire, giving it a low resistance, it seemed to me rather unconvincing that a mere matter of degree—of how much resistance—should account for a difference in kind, between volts and amps. So I am

*"Cathode-Coupled Amplifier," by K. A. Pullen, Jnr., *Proc. I.R.E.*, June 1946, p. 502.

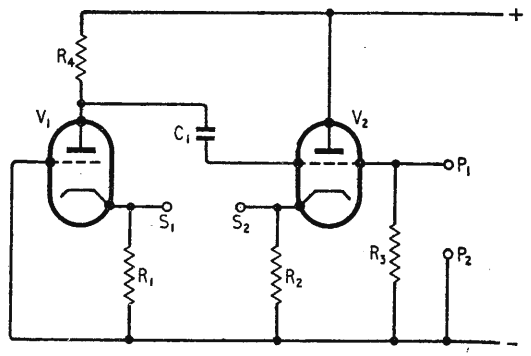

Fig. 3. Practical circuit suitable for providing two different kinds of negative resistance.

anxious that our circuit technician should leave no one with the idea that the distinction between the S and P connections depends on the amount of resistance involved. We know that there is something more far-reaching than that, because increasing the externally connected resistance increases the tendency to oscillate if the P terminals are used, but reduces it if the S terminals are used.

The more significant fact—both with this circuit and the meter question—is the method of connection: series or parallel. It is clear enough from Fig. 4 (or even Fig. 3) which is which, so that may be taken to answer our original Fig. 1 question. But with other types of negative-resistance device—the dynatron, for example—it may not be so obvious. What I would like to know is how one can tell the difference even if the negative resistance is in an unopenable black box and only the two terminals are accessible. If the Fig. 3 circuit were inside, how could one tell whether the terminals were S_1 S_2 or P_1 P_2? (We can assume that if they were P_1 P_2 then S_1 S_2 would be shorted.) An obvious and simple practical way would be to test whether there was an oscillatory voltage between the terminals (in which case they would be P_1 P_2) or had to be joined by a low resistance to obtain an oscillating current through it. But that wouldn't get at the underlying principle.

We still haven't used our cause-and-effect key. Let us try what happens when current and voltage are used as the cause, at each pair of terminals.

If the box contained just ordinary positive resistance, as in Fig. 5, any current made to flow would cause the terminal at which it entered to become positive, relative to the other. And any e.m.f. applied (E) would cause current to flow in the direction shown, out of its own + terminal and into the more positive box terminal. It doesn't matter which is regarded as cause and which effect.

Now suppose the box terminals happen to be S_1 S_2 in Fig. 3. Feeding current into S_1 certainly makes that terminal go positive, for R_1 and V_1 are both positive resistance. But there is a secondary action, for this positive "signal" is amplified by the earthed-grid valve V_1 and passed on via the cathode follower V_2 to S_2, which consequently goes more positive than S_1. So the ultimate result of making current flow from S_2 to S_1 is to make S_2 positive relative to S_1. This, being the opposite to events in Fig. 5, indicates negative resistance.

Next, let us reverse the order and apply an e.m.f. between S_1 and S_2, with the object of making S_2

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more positive than S_1. If what was previously the cause of this effect now became the effect, current would flow from S_2 to S_1, again proving the contents of the box to be a negative resistance. But instead we find that current flows in the direction of the applied e.m.f., from S_1 to S_2, indicating positive resistance.

Clearly, then, the negative resistance must be of the current-operated type only. Because the effect of current fed into S_1 is to make S_2 go positive, we can describe the device in the box as a current-operated voltage generator.

Now let us work out what the results of the same pair of tests would be if the terminals were in fact P_1 P_2. Feeding current into P_1 would make P_1 go positive, just as with S_1. The cathode would follow, most of the way, and being joined to S_1 would make that positive, as before. But this time the amplified positive would arrive at the terminals into which the current was flowing—P_1—which would lead us to conclude that the internal resistance was positive.

But the second test—applying an e.m.f. to make P_1 positive—would again make P_1 go more positive, by amplification, making current flow out from P_1 into the source of applied e.m.f. This would show that the box had negative resistance to voltage only—a voltage-operated current generator, in fact.

One can think of a rough sort of mechanical analogy by supposing a man standing facing one panel representing S_1 or P_1 and with his back to another, representing S_2 or P_2. Distance between them represents potential difference between terminals. If he were to press on the panel in front, and it happened to be S_1, its motion, amplified by a servo-mechanism, would be communicated to S_2, giving him a violent kick in the pants and sweeping him forward, with a minimum of space between the panels. But if it were P_1, that panel would be swept rapidly away from his astonished hands, causing a large inter-panel spacing.

Just as in this analogy the man could tell at once by the feel of the thing which type of mechanism he was up against, so an electrical signal can tell at once which sort of negative resistance it is connected to, even if the number of ohms be the same in both.

The question now (ignoring any hints Fig. 4 may have given, and not attempting to guess what might be behind the choice of letters for labelling the terminals in Fig. 3) is, which kind of negative resistance is which in Fig. 2?

Let us go back to the original question, Fig. 1.

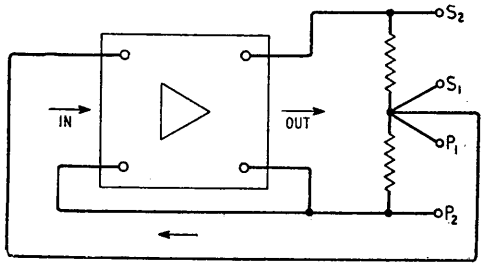

Fig. 4. That the circuit of Fig. 3 is an amplifier in which feedback is introduced by joining S_1 to S_2 is shown by this block diagram, where the respective roles of S_1 S_2 and P_1 P_2 are brought out more clearly by bringing them together into a potential divider.

If R_1 and R_2 were both positive resistances, the circuit would be a merely passive affair, with no current and no voltage anywhere. "Series" and "parallel" would then have no significance. To be in series, the same current must flow through both; to be in parallel, the same voltage must be across both. As I said about Fig. 1 in 1946, in order to answer the question one has to know the position of the generator. When it is in series with the resistors, they are in series with one another; when in parallel, they are in parallel.

If R_1 is a negative resistance, it must in effect contain a generator; otherwise it couldn't feed power into R_2. We have discovered that one kind of negative resistance is a current-operated voltage generator and the other a voltage-operated current generator. Now in Fig. 2(a) it is clear that the negative resistance is behaving as a current generator. It is supplying not only the $\frac{3}{4}$ mA needed to maintain 15 V across the circuit but also $\frac{1}{4}$ mA for export. This corresponds with the behaviour of the Fig. 3 device between the P_1 P_2 terminals. We can therefore say that when that device is connected via P_1 P_2 to a resistor it is in parallel with it, and stability or instability must be calculated accordingly, by the $R_1R_2/(R_1 + R_2)$ formula.

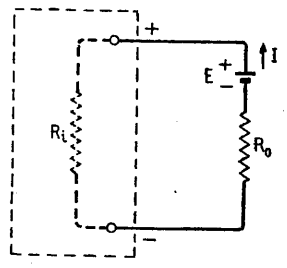

Fig. 5. Polarity of the potential difference between the terminals of a positive resistance when current is driven through it.

Since this type of negative resistance is voltage-operated, the current generated in Fig. 2(b) must be regarded as caused by the 15V across R_1 and R_2. If that voltage is altered, the current alters in direct proportion, in accordance with the meaning of R_1. With our 20-kΩ R_2 connected straight across a 15-kΩ R_1 between terminals P_1 P_2, there is no other parallel path for the surplus current, so it is bound to go through R_2. That raises the p.d. across it, and since the p.d. is the operating agent for the R_1 current generator, more current comes. The p.d. rises more, and so on, until the valves are overloaded, bringing up the value of R_1 until it exactly balances R_2.

If R_2 were less than $-R_1$, say, 10kΩ, it would need 1.5mA to sustain a p.d. of 15V across it; and since that amount of current is not forthcoming from -15kΩ at 15V the p.d. would keep on dropping until it ceased altogether. But at least R_1 would reduce the amount of power that would have to be fed in from elsewhere to maintain any required p.d. across R_2. Of the 1.5mA at 15V, that 15V calls forth 1mA from R_1, leaving only $\frac{1}{2}$mA to be found. Half a milliamp at 15V represents 30kΩ. So the effect of putting a *negative* resistance in parallel with R_2 is to *raise* the combined resistance; in this case, threefold.

If, on the other hand, R_1 happened to be Fig. 3 via S_1 S_2, it would be a current-operated voltage generator. In this event, the 15V across it is the result of the 1mA through it. If this 1mA is to go through the 20-kΩ R_2, however, 5V must be imported to bring the 15V from R_1 up to 20V.

It is interesting to consider how the source of this import affects the situation. If it were a fixed-

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voltage source with negligible internal resistance, its voltage—unlike that of R_1—would be independent of the current flowing through it. This would mean that the current could not be other than 1mA. The 1mA situation would be definitely stable. Without the 5V there would be no current at all, for R_1 alone is unable to maintain any. So the 1mA *appears* to be due entirely to the 5V, leading one to reckon the resistance it is up against as $5/1 = 5k\Omega$, which of course is the same as one gets by adding $-15k\Omega$ to $20k\Omega$.

If, on the other hand, the 5V came from a $-5k\Omega$ resistance—or, what comes to the same thing, R_1 were increased to $-20k\Omega$—the current could be anything. In practice this would not be so, because any practical negative resistance is negative only over a limited range of current, and even within that range is not perfectly linear. So although in theory the current through a circuit having zero resistance would stay indefinitely at any value it was set to, in practice this setting would be unstable, the slightest disturbance causing it to grow or dwindle, according to the way the negative-resistance characteristic curved.

If R_2 were lower than $-R_1$, there would be a net surplus of volts, which could be used elsewhere.

These actions should all be reviewed in relation to some actual negative-resistance device, such as Fig. 3 via S_1 S_2. The voltage across the terminals (15V in Fig. 2(b)) due to the current is easily identified as the amplified voltage delivered at S_2. If S_1 S_2 were bridged by a 20-kΩ resistor, the negative resistance being $-15k\Omega$, any initial current disturbance would at once die out. A 5-V source would however drive 1mA, as if the $20k\Omega$ had been only $5k\Omega$. What really happens, of course, is that for every volt applied externally the "black box" contributes 3 volts unseen. But since we aren't supposed to know what is in the box, the credit for the 1mA goes entirely to the external 5V. Which is why the resistance seems so low.

Note that in order to measure negative resistance by observing the amount of negative current it yields from an applied voltage (or vice versa) it is necessary to prevent it from affecting the measuring gear. So the parallel type must be measured by applying a voltage from a zero-resistance source—a perfect voltage generator—and the series type must be measured by feeding in a current from an infinite-resistance source—a perfect current generator. In practice, this means either approximating so closely to these perfect sources that the difference is negligible (sometimes rather difficult with the current source) or allowing for the imperfection. The plotting of the characteristic curves of the dynatron and transistor was a method of allowing for the imperfection. But the resistance of the source must at worst be respectively lower and higher than the negative resistance to be measured, or the circuit would be unstable. That was why voltage was applied to the dynatron through a low resistance and to the transistor through a high resistance.

It should hardly need mentioning that all the currents and voltages we have been talking about are "signals," over and above any that may be needed to bring the negative resistance device to its working conditions. And with a negative resistance device with reactive couplings, such as Fig. 3, these signals must necessarily be alternating, within a certain range of frequency. To obtain oscillations containing only a single frequency (i.e., of pure waveform) it is necessary to arrange that R_2 is on the stable side except at that one frequency.

This at once suggests acceptor and rejector circuits, for the acceptor has a low resistive impedance at one frequency and a higher impedance at all others (Fig. 6(a)), and the rejector has a high resistive impedance at one frequency and a lower impedance at all others (b). The trick, of course, is to adjust the amount of this resistive impedance —or, more usually, the negative resistance—until it is just balanced out by the negative resistance. If that were done too perfectly, the amplitude of oscillation would fluctuate at every slight change of resistance, so in practice the net circuit resistance is given a reasonable margin on the negative side, making the oscillation amplitude grow until it restores the balance itself; by driving a valve round its bend, for instance.

The lower a negative resistance of the parallel type, the easier it is to get high-loss (i.e., low-impedance) LC circuits to oscillate. It may seem rather surprising that a circuit that cannot be made to oscillate by connecting directly to the negative resistance can be made to do so by adding positive resistance in series. Take an LC circuit whose resistance at resonance is only $12k\Omega$, in parallel with a negative resistance that cannot be made numerically less than $-15k\Omega$. Total parallel resistance is positive; no oscillation. But if $3k\Omega$ is put in series with the LC circuit the total positive is brought up to $15k\Omega$, enough to bring it to the threshold of oscillation. By this means it would seem possible to make the most inefficient circuit oscillate with the feeblest negative resistance. But, as one always suspects when one seems to be getting something for nothing, there are snags, which increase with the resistance gap to be filled. The resonance curve of the LC is made even flatter, and there may be trouble with stray reactance in connection with the series resistance.

With series negative resistance, an acceptor circuit with too much resistance to oscillate can correspondingly be persuaded by resistance-shunting it.

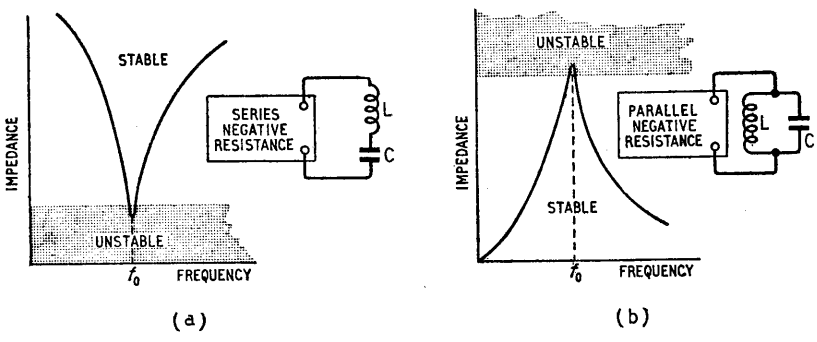

Fig. 6. Arrangement of frequency-determining circuit LC to oscillate at frequency f_0 with (a) series and (b) parallel type of negative resistance.

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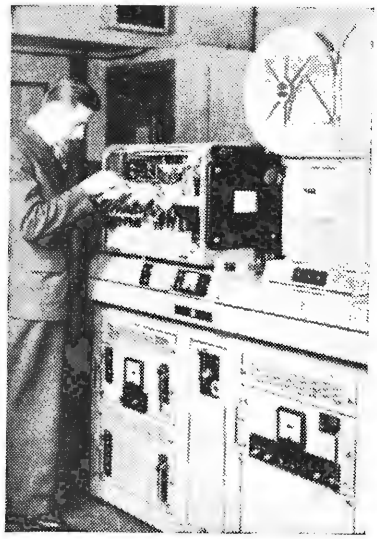
Technical Notebook

High-Quality TV Recording is obtained with a new Marconi equipment in which the 16-mm film is mechanically pulled down in the brief blanking period between television frames. This is only 1.4-1.8 milliseconds. Hitherto the pull-down times in conventional interrupted cameras have been too long to make this possible, and the usual practice has been to record only alternate television frames and use the intervals between for pulling down the film. This means that only half the picture information is recorded in the picture period and there is consequently a reduction in quality. Another system of recording, in which the film is moved con-



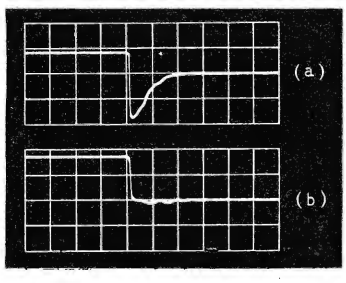
tinuously, does give the full picture information, but has mechanical and optical disadvantages from the operational point of view. The B.B.C. have recently installed one of the new Marconi equipments for test purposes.

Cyclotron Type Valve used for detecting presence of electromagnetic waves at about 3,000 Mc/s. An analysis of the performance is given by P. G. Baird in a D.S.I.R. unpublished report.

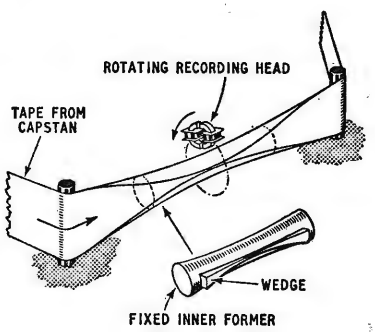
Ferrites for V.H.F., with initial permeabilities of the order of 10, at all frequencies up to 500 Mc/s, have been developed and are reported by G. H. Jonker, H. P. J. Wijn and P. B. Braun, in *Philips Technical Review* for November 1956. The new materials, to be known as Ferroxplana, are more closely allied to Ferroxdure (a permanent magnet ceramic) than to the "soft" Ferroxcube, and have a hexagonal rather than a cubic crystal structure. But whereas the Ferroxdure materials have a *preferred* direction of magnetization along the hexagonal axis, in Ferroxplana this is an *abhorred* direction and magnetization is easiest in any direction in a plane at right angles to the hexagonal crystal axis. Of greater practical importance is the fact that the ferromagnetic resonance frequencies of the Ferroxplana materials, for a given initial permeability, are five times higher than Ferroxcube, with a corresponding extension of the working range. The resistivity and saturation magnetization of the new materials are said to be of the same order as in Ferroxcube.

Feedback Stabilized Servo system using the back e.m.f. of the d.c. drive motor, separated from the power supply circuits, as the feedback signal. A D.S.I.R. unpublished report by J. Leeder.

Avalanche Junction Diodes are semiconductor devices, generally used for switching or pulse work, which utilize a current-multiplying "breakdown" effect rather like the sudden ionization in a gas discharge tube. Normally, junction diodes have a slow response when they are rapidly switched from forward voltage to reverse voltage, because storage of current carriers prevents the diode current from immediately falling to its normal reverse-voltage value, as shown at (a). A certain recovery time is necessary, which sets a limit to the operating p.r.f. The avalanche diode, however, works with a reverse bias just short of the breakdown voltage, instead of at zero voltage, and the applied switching pulse initiates the avalanche effect. But since the diode voltage is never reversed and there is a strong electric field maintained by the bias, the time taken for the electron and hole products of the avalanche to be absorbed in the respective n and p layers is very short. There is no storage, in fact, and the recovery characteristic is improved as in (b), the time scale being 0.1 μsec per square. A discussion on the use of existing diodes in this way is published in a letter from J. E. Scobey, W. A. White and B. Salzberg in *Proc.I.R.E.* for December, 1956. Special avalanche diodes have been developed by Bell Telephones, however, with closely controlled characteristics. Their breakdown voltage, for example, can be predicted and controlled in production to within about 5 per cent.



Television on Tape.—The main problem in recording signals of 3-Mc/s bandwidth by conventional methods on magnetic tape is, of course, the high speed at which the tape must run in order to resolve the information. In the RCA recording equipment, for example, it is 20 ft/sec. Various suggestions have been made for avoiding this by recording transversely with a moving head *across* a wide tape, the idea being that while the effective speed remains high the actual longitudinal motion of the tape over the capstans can be reduced to about 15 in/sec. The Ampex equipment in America uses this principle. All the schemes depend on rotating heads or fixed heads with rotating pole-pieces. One suggestion on how the tape can be arranged for a rotating head has been sent to us by R. M. Larsson. After leaving the capstan the tape is fed between formers (only the inner one is shown) which bend it round into a tubular shape. Beyond the recording head it returns to its flat state. The information is actually recorded on the "tube" in the form of a spiral, but on reverting to the flat state this becomes a series of almost straight rows across the tape. To keep the tape in con-



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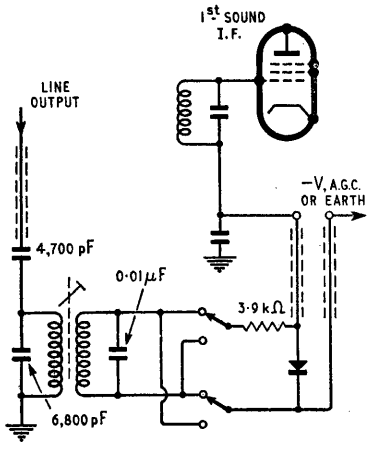
tact with the recording head Mr. Larsson suggests that compressed air should be fed into the inner former (which would be hollow) to emerge through a circumferential gap corresponding with the head rotation. This would then press the tape gently against the rotating head assembly.

Bilingual Television.—A French system for providing two different sound accompaniments to the picture was described in our last issue (p. 79) and it was mentioned that only a very simple and inexpensive "decoder" unit was required in the receiver. A full account of this gating device has actually been published in the January, 1957, issue of *Télévision* (see diagram). An LC circuit is shock-excited from the line output stage and is coupled to another LC circuit which gives an almost pure sine wave shifted in phase by 90°. The switch is used to reverse the phase of this sine wave (depending on which of the two interlaced pulse trains in the sound channel is to be gated), while the semi-conductor diode limits the positive peaks to produce flat-topped gating pulses. These are available at the output terminals of the unit, which, as shown, are simply wired into the grid circuit of the first sound i.f. stage.

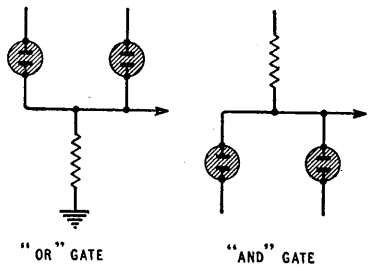


Multi-Element Diodes and bi-stable devices constructed from semiconductor materials. A brief summary by E. B. Dale, M. W. Aarons, M. Pobereskin and J. E. Gates in a D.S.I.R. unpublished report.

Vertical Scanning Radar for aircraft has been suggested by L. J. Battan, of Chicago University, as a means of avoiding icing conditions and for giving a continuous picture of the terrain below for clearance purposes. Normally, of course, airborne cloud-and-collision warning radar scans in azimuth, though it can be tilted up and down slightly. In a report in *Aeronautical Engineering Review* for December 1956, Mr. Battan discusses the results obtained from a 3-cm airborne equipment modified so that it scans in a plane perpendicular to the flight path, and he gives photographs of typical responses on the c.r.t. screen. The height of clouds and terrain can be measured in this way, while the detection of possible icing conditions in the clouds depends on the fact that ice particles have only one-fifth of the reflectivity of water droplets of the same size. The ideal arrangement, of course, is a radar set which will scan in both vertical and horizontal planes.

Magnetic-Coupled Multivibrator in which the magnetic core is used for controlling the frequency of operation in inverse proportion to the magnetic flux. Unpublished report by R. L. Van Allen, available from the D.S.I.R.

Neon Computing Elements.—The ordinary neon tube, as an "on-off" two-state device, may have advantages for use in the logical "OR" and "AND" gates required in great numbers in electronic digital computers. It is considerably cheaper than the semiconductor or thermionic diodes commonly used, and in the gate circuits it is relatively insensitive to variations of characteristics between different tubes. The two circuits illustrated are taken from a comprehensive study of the possibilities by C. E. Hendrix in *I.R.E. Transactions* CP-3 for September, 1956. In the "OR" circuit, a positive pulse is produced at the output if either of the tubes is fired by a positive pulse applied to its upper plate. In the "AND" gate, a positive output pulse is only produced if both of the neons have positive pulses applied to their lower plates to reduce the p.d. and prevent them from firing. (Otherwise, when either of the neons is fully conducting, the output is reduced to the voltage across the tube.) One disadvantage arises from the "stabilizing" voltage across the tubes when they are fully conducting. This means that the output level in the "OR" circuit is always a good deal lower than the highest input voltage, while in the "AND" circuit it is always a good deal higher than the lowest input voltage. Another difficulty is the comparatively slow response of the glow discharge, which limits the operating p.r.f. to about 30 kc/s.



Semiconductor Camera Tube for television, devised by J. R. Pierce, of Bell Telephones, is comparable with the image orthicon except that its target consists of a thin wafer of germanium or silicon instead of glass. This is coated on the lens side with a thin transparent layer of metal through which the optical image passes, while the other side is scanned by a low-velocity electron beam. An image focused on the target produces hole-electron pairs in the semiconductor. The electrons move towards the metal layer while the holes are repelled towards the semiconductor surface, where they become trapped. This gives a positive charge pattern, corresponding to the optical image, which modulates the scanning beam. The return beam therefore carries the video information, and it passes through an electron-multiplier (near the cathode) which gives the video signal at its output. High sensitivity, output and resolution are claimed for the tube, of which a diagram is given in the January 1957 issue of *Radio-Electronics*.

Magnetic Field Regulation by a feedback control system using the phenomenon of nuclear magnetic resonance for sensing purposes. A D.S.I.R. unpublished report by F. A. Hadden.

"Through" Electron Multiplier, in which the secondary electrons are generated not from the front surface of the dynodes but by transmission *through* a series of thin insulating layers, has been developed by E. J. Sternglass and M. M. Wachtel, of Westinghouse in America. The insulating dynodes consist of layers of potassium chloride spaced 0.2 inch apart. They are faced with very much thinner layers of gold, which serve to scatter the incident electrons so that they expend more energy in the insulator and give a greater yield of secondaries. The device has advantages for amplification of high-speed pulses, since the uniform length of all electron trajectories and the close dynode spacing (as well as higher accelerating voltages between dynodes) result in a greatly reduced "spread" of the pulse rise-time during multiplication. The main disadvantage at present is the high rate of deterioration of the dynodes under electron bombardment. A full account is given in *I.R.E. Transactions*, NS-3, for November 1956.

Unpublished Reports mentioned above come from various sources but can be obtained from the Technical Information and Documents Unit of the Department of Scientific and Industrial Research, 15, *Regent Street, London, S.W.*1.

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Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

Whip Aerials

THE latest whip aerials made by Antiference are fitted with a new type vertical rod consisting of three 6ft lengths of tough aluminium alloy tube tapering from ¾in at the base to ½in at the top and joined by reducing ferrules designed to withstand winds up to 80 m.p.h.

One model, known as the "Extat," is fitted with screened downlead and matching transformers covering 10 to 2,000 metres and is for use where electrical interference is troublesome. Elsewhere the companion "Vra" model, which is a plain whip type, is suitable.

With chimney lashings the "Extat" costs £9 12s and the "Vra" £4 3s 6d; with wall brackets the prices are slightly less.

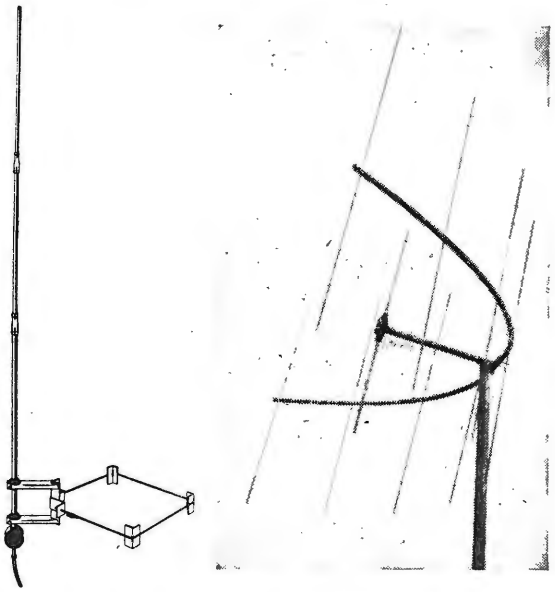
The makers are Antiference, Ltd., Bicester Road, Aylesbury, Bucks.

Parabolic Band-III Aerial

THE illustration shows an unusual type of Band-III television aerial. It consists of a single vertical dipole mounted at the focal point of a parabolic array of eight reflectors. Relative to a plain dipole the forward gain is given as 14 dB, its back-to-front ratio as 36 dB and the acceptance angle 20°, measured to the half-power points.

The comparatively narrow acceptance angle (in azimuth) ensures rejection of unwanted signals and interference of one kind and another, over an unusually wide angle.

Mechanically the aerial seems soundly designed and should stand up well to all weather conditions. It is made by The Meadows-Dale Manufacturing Co., Ltd., The Dale, Willenhall, Staffordshire, and the price is £10 10s with a 10ft mast and double chimney lashing.



Left: New "Extat" vertical rod aerial made by Antiference. Right : Dale parabolic Band-III television aerial.

Band-III Signal Intensity Meter

A COMPACT and portable a.c.-operated meter for measuring the average television signal intensities on Band III has been introduced by Radio-Aids. It can easily be taken to the site where it is proposed to erect the aerial in order to ascertain the type of aerial required and whether the chosen site is the best one or not.

Similar in general design to the Band-I model introduced some time ago, it uses a t.r.f. circuit consisting of four cascode r.f. stages, a germanium diode detector, sensitive microammeter and voltage-stabilized power supply. Thermistor compensation for temperature variation is included.

Full-scale meter readings are 200 μV, 2 mV and 20 mV respectively, the three ranges being selected by plugging the aerial feeder into one of three sockets used in place of switching.

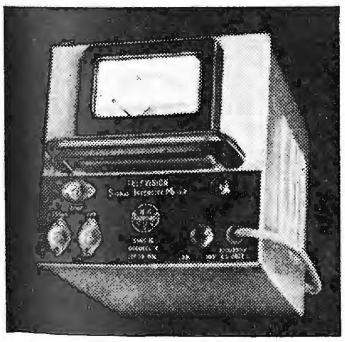
Known as the Type SIM III, the instrument weighs 8 lb, measures 7in × 6in × 6in and costs £33. It is obtainable from the sole distributors, W. J. Picton (Heath Electronics), Ltd., 57, High Road, Bushey Heath, Watford, Herts.

Compact Marine Transmitter

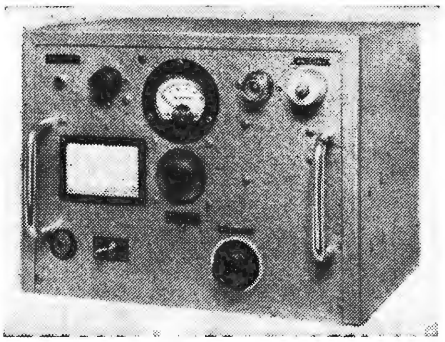
A VERY compact 25-watt 'phone and c.w. marine transmitter, measuring only 12in × 9in × 10in, has been introduced by Sea Wave Communications for use in the smaller types of vessel. It provides immediate choice of any one of six crystal-controlled frequencies in the band 2 to 18 Mc/s and the marine distress frequency of 2,182 kc/s is separately marked for instant selection. Aerial matching on changing channel is reduced to the simplest possible operation.

A land-station version of this marine MTX25 model will be available shortly and this will provide 25 watts telephony and 40 watts c.w. and both variable master oscillator and crystal control will be embodied.

The transmitter is obtainable from Sea Wave Communications, Ltd., 13, South Molton Street, London, W.1. The price of the marine transmitter, MTX25, is £65 complete.



Radio-Aids Band-III TV signal intensity meter.



Sea Wave Communications marine transmitter, Type MTX25.

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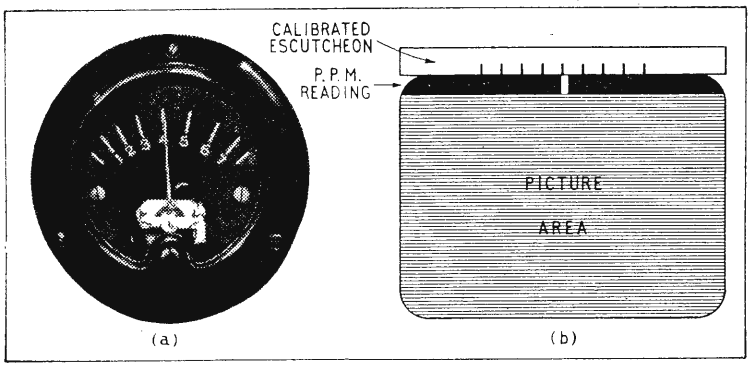

Fig. 1. (a) Dial of the B.B.C. peak programme meter; (b) the corresponding display on the monitor tube face.

Picture-

By

J. R. GREENWOOD,* B.Sc.

WHEN monitoring television programmes it is difficult to keep both sound and picture monitors in view at the same time. The reason for this is, of course, that while the picture is displayed on the screen of a cathode-ray tube the peak levels in sound output are indicated by the pointer of a separate meter movement operating as a peak-reading voltmeter.

Obviously, presenting the indication of programme sound intensity on a portion of the monitor tube face is the logical way to overcome the difficulty. Viewing a constantly changing sound waveform on the face of a c.r. tube, however, causes a good deal of eyestrain. Before the war a special sound processing circuit which lessened eyestrain was developed by the B.B.C. This piece of equipment is called a "peak programme meter" and has proved very satisfactory in all respects when driving the meter movement mentioned previously. This article will describe the additional equipment required to display the peak-programme-meter readings on the c.r. tube without interfering with the c.r. tube's primary purpose of showing the transmitted television picture.

In Fig. 1 can be seen the dial of the existing peak programme meter, while alongside is a sketch of the corresponding type of indication provided on the c.r. tube face. Modifications to the front panel of the picture monitor entail only the provision of a calibrated escutcheon, which takes the form of an approximately evenly tempered scale calibrated from 1 to 7, that is, a 6 dB step between 1 and 2, and 4 dB steps per division over the rest of the scale.

Fig. 2 is a schematic diagram of the existing sound processing circuit. The main objective is to have a continuous indication of the peak voltages to which the main programme chain equipment will be subjected when a sound signal is being transmitted, and, at the same time, to avoid affecting the performance of the main chain. The indications of most value are:—

(a) The line-up condition, which represents 40% modulation of the transmitter. This is on meter reading "4," when 1000-c/s line-up tone is fed along the programme chain prior to transmission.

(b) Maximum signal condition, which represents 100% modulation. This is on meter reading "6."

(c) Minimum permissible signal condition, which is controlled by the optional minimum signal/noise ratio thought to give satisfactory radio reception. This is on meter reading "1."

Sound Processing Systems

The isolating pre-amplifier protects the signal proceeding along the main programme chain from being affected by the non-linear input impedance of the double-diode rectifier and timing circuit, which would otherwise cause harmonic distortion to appear on the sound signal fed to the transmitter. The rectifier and timing circuit takes the sound signal and processes it so that the feed to the law conversion stage carries only the information necessary to ensure the accurate registration of peak voltages on the meter. The circuit will be dealt with in more detail later.

The logarithmic law conversion stage is necessary on account of the ear's logarithmic response to varying sound intensities, which implies a very wide range of audible sound intensities to be compressed within the permissible programme dynamic range. In consequence, the broadcast engineer is concerned with obtaining as wide a dynamic range as possible; the accepted figure, for the present, being in the region of 30 dB, with possibilities of slight extension where only f.m. transmitters and receivers are used. The programme meter has to give accurate indication of peak voltages over the entire dynamic range with some divisions to spare at either end of the scale.

In order to avoid a long technical description of the peak programme meter (which is only incidental to this article) it is sufficient to show the type of

* B.B.C. Engineering Training Dept.

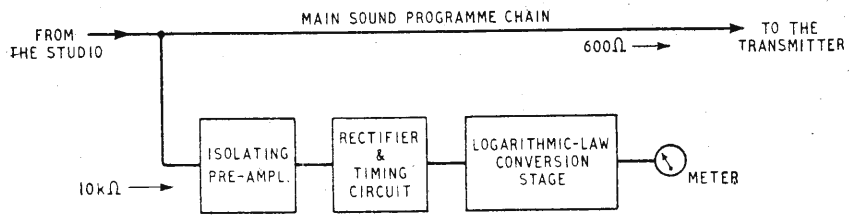

Fig. 2. Schematic of B.B.C. sound processing circuit used for the peak programme meter.

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Tube Sound Monitoring

METER-TYPE DISPLAY ON THE RASTER OF A TELEVISION MONITOR TUBE

waveform which will be fed into the system as the "processed sound signal." Fig. 3 shows the response of the peak programme meter to a given input signal. The waveforms demonstrate that the timing circuit has a fast registration time, so that peak values are recorded faithfully, and a slow discharge time constant (1 second), so that extraneous meter-needle movement is reduced to an extent where eyestrain is greatly diminished. A signal of approximately 215 volts peak value having a waveform as in Fig. 3(a) is available at the output terminals of the programme meter, the generator impedance being approximately 150 kΩ.

From Fig. 1(b) it can be seen that the type of indication required necessitates a number of beam brightening pulses being formed. These will have to occur during a portion of each of the first few lines of each frame of the raster. The objective is to form a vertical bright bar covering a portion of the first 10 successive picture lines. The bar has to be positioned relative to the escutcheon so that the instantaneous value of the processed sound signal voltage can be seen clearly.

The phasing of the brightening pulse with respect to the line scan is actually achieved by a coincidence circuit. Each value of voltage on the processed sound waveform has an equivalent value on the slope of the line sawtooth, and the coincidence circuit produces a beam brightening pulse of short duration whenever the equivalence is satisfied. The general principle can be followed with the aid of Figs. 4, 5 and 6. In Fig. 4, one signal input is derived from the line sawtooth generator and the other from the processed sound signal source. The points of coincidence are shown in Fig. 5(a) and (b). Here, A and C are the ones of interest; B and D have no significance and occur during flyback. Fig. 6 shows the effect as seen by the observer, illustrating that the spot moves from position A at time t_1 to C at t_2 according to the value of V_2 at the respective times.

Independent Sound Presentation

The television waveform is of a highly complex nature. One feature of the waveform which initiated this idea is that, prior to the commencement of active picture elements of the signal, 8 broad pulses and 10 suppressed lines are radiated in order that the average receiver or monitor frame timebase will have more than ample time to return the electron beam to its starting position at the top of the tube before the next frame becomes "active."

That is the reason why the sound indicating system can be superimposed on the television picture monitor tube face without interfering with the picture. However, up to this point no mention has been made of the suppressor circuit which is included in the complete schematic diagram of the system, Fig. 7.

The action of the suppressor circuit and pulse amplifier combined is to suppress brightening pulses from the coincidence circuit whilst the active lines

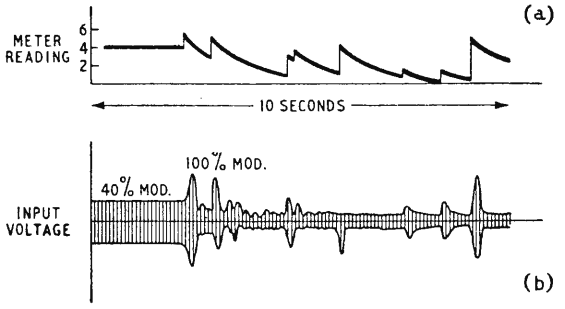


Fig. 3. (a) The response of the peak programme meter to an input signal (b).

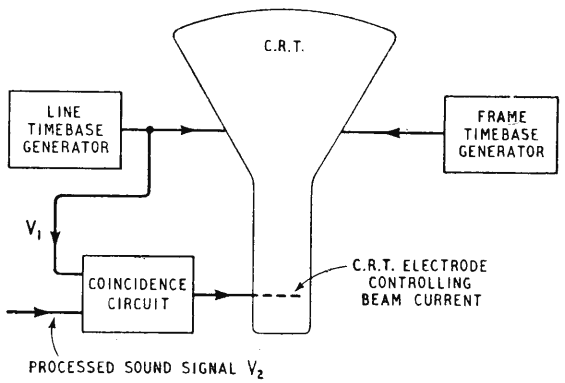
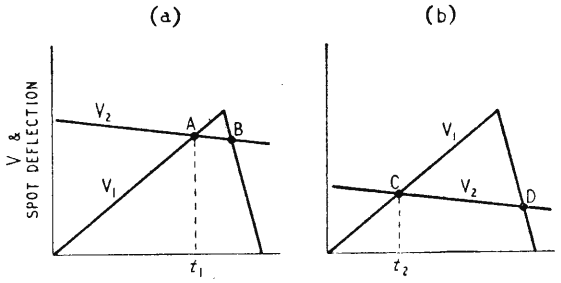
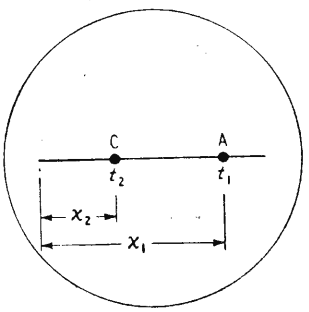


Fig. 4. Schematic showing the basic principle of the c.r. tube indication system.



Above: Fig. 5. Points of voltage coincidence on the waveforms of the frame timebase and the processed sound signal, at two different times (a) and (b).



Left: Fig. 6. Positions of the brightened spot across the tube face at times corresponding to t_1 and t_2 in Fig. 5.

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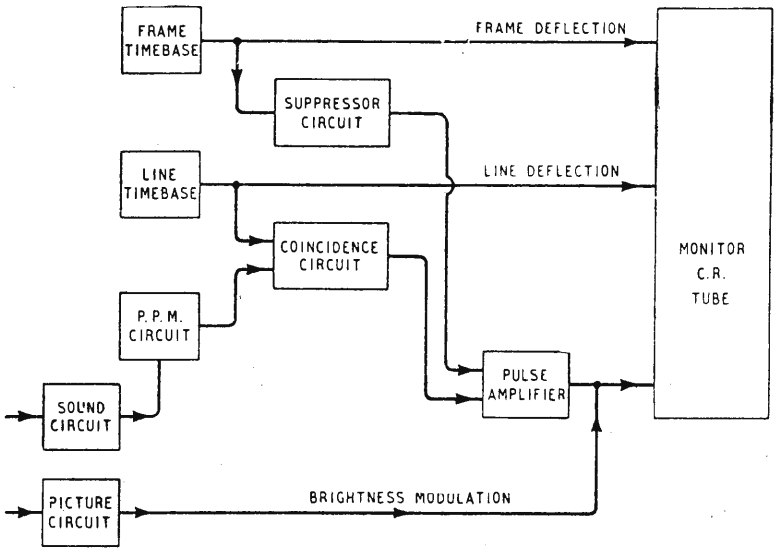

Fig. 7. Schematic of the complete indicating system.

constituting the centre of the picture are being displayed. The suppressor is fed from the frame timebase and is arranged to derive a signal of approximately 1 to 2 milliseconds duration. Only during this time does the pulse amplifier pass the brightening to the appropriate electrode on the c.r. tube to give the indication shown in Fig. 1(b).

Whilst the sound signal is being processed in the peak programme meter circuit to provide one signal input to the coincidence circuit, the output signal from the monitor line timebase is used to deflect the c.r. tube beam and as a second signal input to the coincidence circuit. The sound signal input has a registration time-constant of 1 millisecond and a discharge time-constant of 1 second. The two input signals act on the coincidence circuit so that a pulse of the order of 1-μsec duration is produced. The coincidence circuit takes care of the phasing of the pulse so that the positions of the brightened spots on the tube face are related to the peak programme meter output.

The pulse amplifier is normally biased-off during the active lines of the picture and only becomes operative immediately after the suppressor circuit receives the frame flyback signal. During the period of flyback the suppressor is supplied with a voltage pulse from the frame timebase circuit. The voltage so derived is stored in a CR circuit having a time-constant of 1 to 2 milliseconds. The time-constant of the storage circuit is so chosen that the normally inactive pulse amplifier comes into operation over the period of the remainder of 10 following inactive lines of the raster.

Since the line frequency is approximately 10 kc/s (the total duration of 10 lines is about 1 millisecond and the time-constant of the peak programme meter discharge circuit is one second), the 10 consecutive brightening pulses for each individual frame will be in the same phase relationship to the line sweep voltage and the 10 spots produced will be in a vertical line.

The phase relationship will not change greatly between frames except at times when a sound peak is in the process of being registered. So that, on a long-term basis, the visual effect will be one of observing the moving bright bar slowly drifting from right to left whilst the peak programme meter registration circuit is discharging after each successive charge brought about by a peak of programme volume. The times when the bar will be visible are separated by only extremely short intervals during which time the peaks are being registered, therefore the indication is almost continuous as shown by the thickened lines in Fig. 3(a).

One of the advantages of the system is that the space occupied by the extra information on the tube face is utilized only on those monitors which need to be fitted with the sound indication. The television waveform in the main chain and in all subsidiary chains remains unaffected and the 10

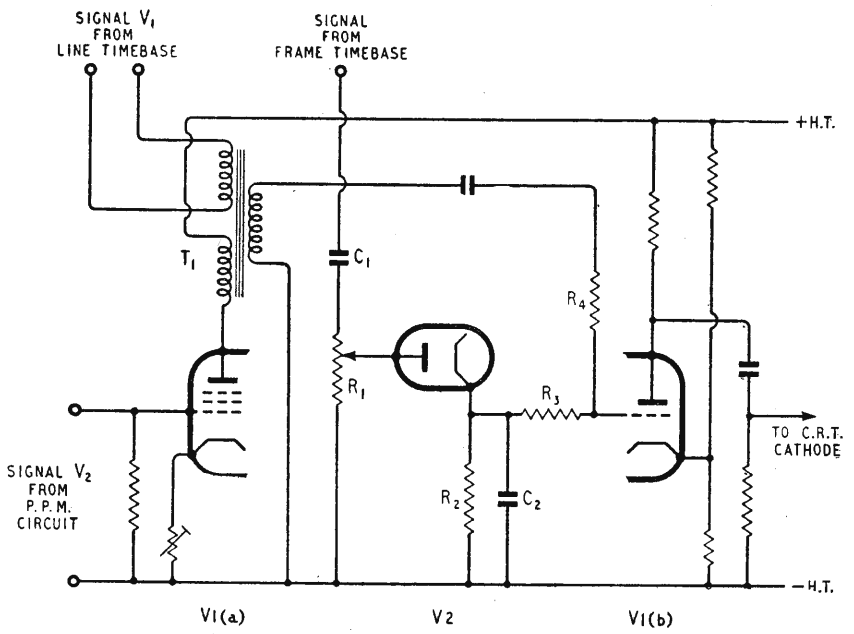

Fig. 8. Circuit for the coincidence detector, suppressor and pulse amplifier shown in Fig. 7.

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suppressed lines would remain available for carrying other information such as stepped light wedges. Also, if the facility is no longer required at a particular point it can be readily discontinued simply by disconnecting the sound input.

In the following part of the article a scheme is suggested upon which the design of the subsidiary apparatus required to convert an existing monitor can be based. The design is in its most basic form and is only one of many systems which would probably work quite successfully.

The problem to be solved, then, is one of producing pulses, for trace brightening purposes, in the period when the picture signal is suppressed at the start of each picture frame. In order to obtain pulses in the correct time sequence to provide an intelligible visual indication of sound output, a coincidence circuit has been suggested. During the part of the frame made up by active lines the above pulses will have to be suppressed.

Brightening-pulse Circuit

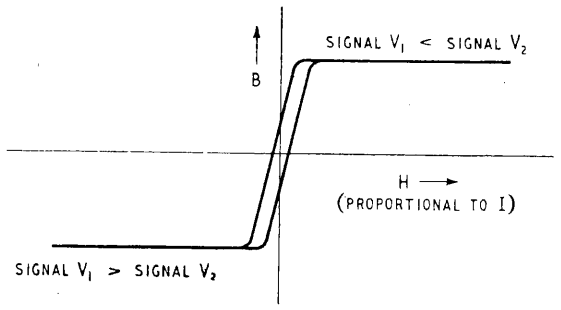
The circuit in Fig. 8 is one example of the many that could be used. Here, T_1 is the heart of the circuit, and should possess a good high-frequency response together with a magnetic core which is easily saturated. Ferrite cores such as Ferroxcube seem to have the desired properties. Also, peaking transformer techniques appear to be of assistance.*

The two input signals are arranged to oppose each other and the one which predominates produces a saturating magnetic flux in the core. The core is, in fact, saturated over almost all of the cycle of events. However, just at the point of change-over, when the signals are very nearly equal, the polarity of the magnetic flux will reverse (Fig. 9). The third winding of the transformer is connected so that the change of flux at the coincident point A (Fig. 5) produces a positive-going pulse at the grid of valve V1(b). This polarity of connection ensures that pulses produced at coincidence point B will be negative-going and therefore have no effect. It is arranged so that the amplitudes of the positive-going pulses alone are insufficient to cause V1(b) anode current to flow. V1(b) has a high positive bias on the cathode (say 50 volts) so that it is cut off.

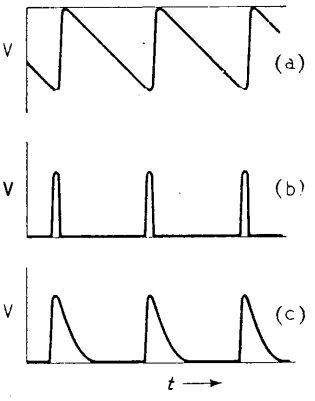
It is required that the pulses will only take effect on the part of the frame immediately following flyback. This is taken care of by deriving a voltage from the frame timebase generator, Fig. 10(a), and differentiating it by the action of R_1C_1 (b), then sustaining the positive-going pulse by the action of R_2C_2 in conjunction with V2, as at (c). The action of V2 is of particular interest because it operates in the same way in both the rectifier and timing circuit of the peak programme meter and in the suppressor circuit. Its action can be easily followed if we think of the input signal in terms of a squared pulse.

If the frame timebase waveform is such that flyback takes a time equal to the duration of two lines the voltage across R_1 will be a squared pulse of 0.2-msec duration occurring at the rate of 50 pulses per second. And if the diode is considered to have a characteristic as shown in Fig. 11 its r_a will be a constant corresponding to the slope of the line. Then for the duration of each pulse the equivalent circuit will appear as in Fig. 12. And since R_2, R_3 and R_4 (as will be shown later) are greater than $R_{gen}+r_a$ the simplification of the circuit to series CR does not unduly affect the issue.

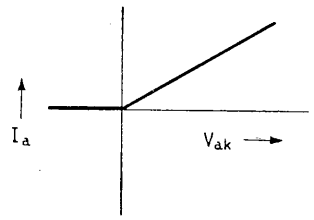
Whilst the charging voltage is present between times A and B, capacitance C_2 will be charged with an exponential rise in terminal voltage and, if the time-constant is chosen correctly, will charge to 90% of the applied voltage in 0.2 msec. As soon as the charging pulse has ended the cathode retains its positive potential after the potential has disappeared at the anode. Hence the diode V2 presents an open



Above: Fig. 9. Change-over of magnetic flux in T_1 of Fig. 8 from one state of saturation to the other when signals V_1 and V_2 become equal.

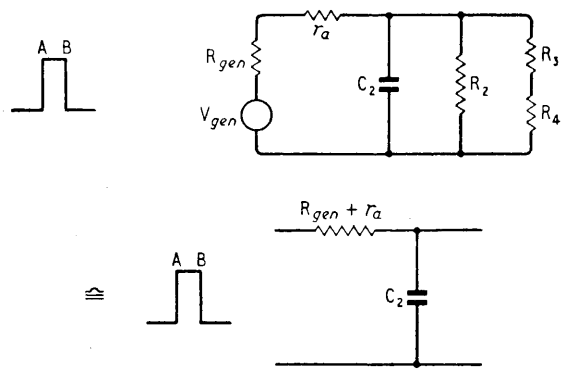


Right: Fig. 10. Voltages derived from the frame sawtooth (a) for gating purposes: (b) after differentiating, (c) after lengthening.



Left: Fig. 11. Characteristic of the diode V2 in Fig. 8.

Below: Fig. 12. Equivalent circuit of the diode gating system.



* "The Design of a Peaking Transformer," by Adin B. Thomas. *Brit. I.R.E. Journal*, October, 1953, p. 486.

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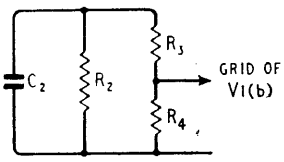
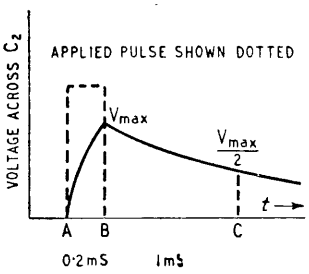
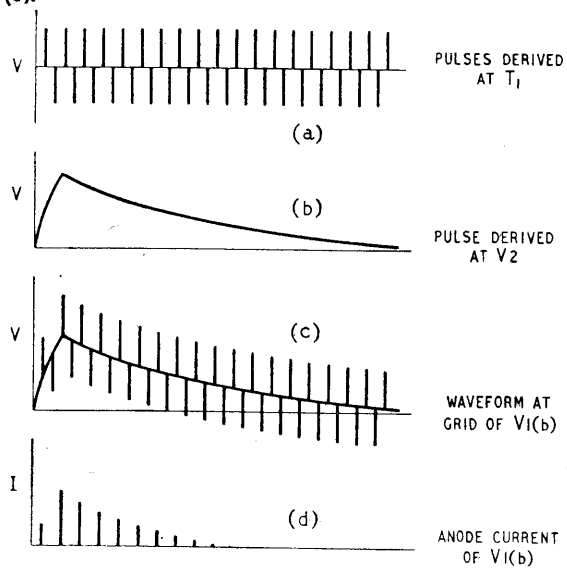


Fig. 13. Effective portion of the gating circuit remaining when the diode presents an open circuit.

Right: Fig. 14. Behaviour of the circuit in Fig. 13.



Below: Fig. 15. Combination of waveforms from T_1 and V2 producing the waveform (c) at the grid of V1(b) and the resultant anode current pulses (d).



circuit, and the effective portion of the circuit remaining, being of the form shown in Fig. 13, behaves as shown in Fig. 14.

It has to be arranged that the discharge of C_2 will take 1 msec to reach 50% of maximum value in order that the grid of V1(b) will become positive with respect to the cathode when each of the first 10 beam brightening pulses arrives from T_1.

Then $C_2\left[\frac{R_2(R_3+R_4)}{R_2+R_3+R_4}\right]$ is 1 to 2 msec

and $C\,(R_{gen}+r_a)$ is about 0.1 msec

and the initial assumption that $\frac{R_2\,(R_3+R_4)}{R_2+R_3+R_4}$ is greater than $R_{gen}+r_a$ is correct.

At this point it requires little imagination to see how a full-wave rectifier can be used in the peak programme meter rectifier and timing circuit to produce the waveform shown in Fig. 3(a) from that in (b).

To continue the argument, the waveform seen in Fig. 15(b) is applied to the grid of V1(b) via R_3 and that seen in (a) via R_4. The resultant effect is to allow pulses of anode current to flow in V1(b) at times corresponding to the times of the first 10 scanning lines as shown in (d). Without going into too great an amount of detail, it can be said that the pulse width of pulses derived at T_1 will have to be in the region of 1 μsec, otherwise the visual indicating bar will be too large on the monitor tube face. It can also be deduced that C_2R_2 will have to be in the region of 1 to 2 milliseconds.

An interesting point to notice is that with this circuit, unlike some others, the size of successive pulses of V1(b) anode current are in diminishing order. The effect on the tube face will be to produce a bar of unequal brightness, the bottom end of the bar being least bright and blending into the top of the picture below it. This is advantageous because it means that the spot may be allowed to stray on to the top few active lines of the picture without causing too great a distraction.

Finally, the author would like to express his thanks to Dr. K. R. Sturley, head of the Engineering Training Department of the B.B.C., and his staff, for their helpful criticisms and suggestions.

CLUB NEWS

Birmingham.—The March programme of the Slade Radio Society includes "Circuit applications of transistors" by J. Chandler and A. Wates, of B.T.H. (1st); a talk on the radio amateur emergency network by A. E. Matthews (15th); and "Radio direction finding" by N. B. Simmonds (29th). Meetings are held at 7.45 at Church House, High Street, Erdington. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Bury.—A. A. H. Moss (G8VF) will give a talk on receivers at the March 12th meeting of the Bury Radio Society to be held at the George Hotel, Kay Gardens. Sec.: L. Robinson, 56, Avondale Avenue, Bury, Lancs.

Chester.—March meetings of the Chester & District Amateur Radio Society include a description of a double superhet on the 19th. The club, which meets at the Tarran Hut (Y.M.C.A.), has decided to grant free membership to "juniors who have no income." Sec.: D. Rickers, 97, Ruabon Road, Wrexham, Denbigh.

Derby.—Meetings of the Derby and District Amateur Radio Society are held each Wednesday at 7.30 at 119, Green Lane. The March meetings include "My recent trip to U.S.A.," by T. Darn (G3FGY) on the 6th, Mullard film strip "The story of television" (13th) and a demonstration, film and discussion on frequency modulation (27th). Sec.: F. C. Ward (G2CVV), 5, Uplands Avenue, Littleover, Derby.

Newbury.—"Colour television—the problems" is the title of the paper which C. A. Marshall, of *British Communications and Electronics*, is reading at the March 22nd meeting of the Newbury and District Amateur Radio Society. The meeting begins at 7.30 at Elliott's Canteen, West Street. Particulars of club activities are obtainable from 83, Newtown Road, Newbury, Berks.

Wellingborough.—At the March 7th meeting of the Wellingborough and District Radio and Television Society M. Homer will deal with television interference. Meetings are held each Thursday at 7.30 at Silver Street Club Room. Sec.: P. E. B. Butler, 84, Wellingborough Road, Rushden.

During the International Jamboree at **Sutton Coldfield** (August 1st-12th) to mark the jubilee of the foundation of the Boy Scout movement, an amateur radio station will be operated at the camp by a group of amateurs. Arrangements are in the hands of an organizing committee including representatives from the Slade Radio Society, Midland Amateur Radio Society and the Birmingham group of the British Amateur Television Club.

***WIRELESS WORLD* INDEX**

The index to the material published in Volume 62 of *Wireless World* (1956) is now available. It includes both general and classified indexes and is obtainable from our Publishers price 1s (postage 2d).

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Ionosphere Review, 1956

Approaching Sunspot Maximum

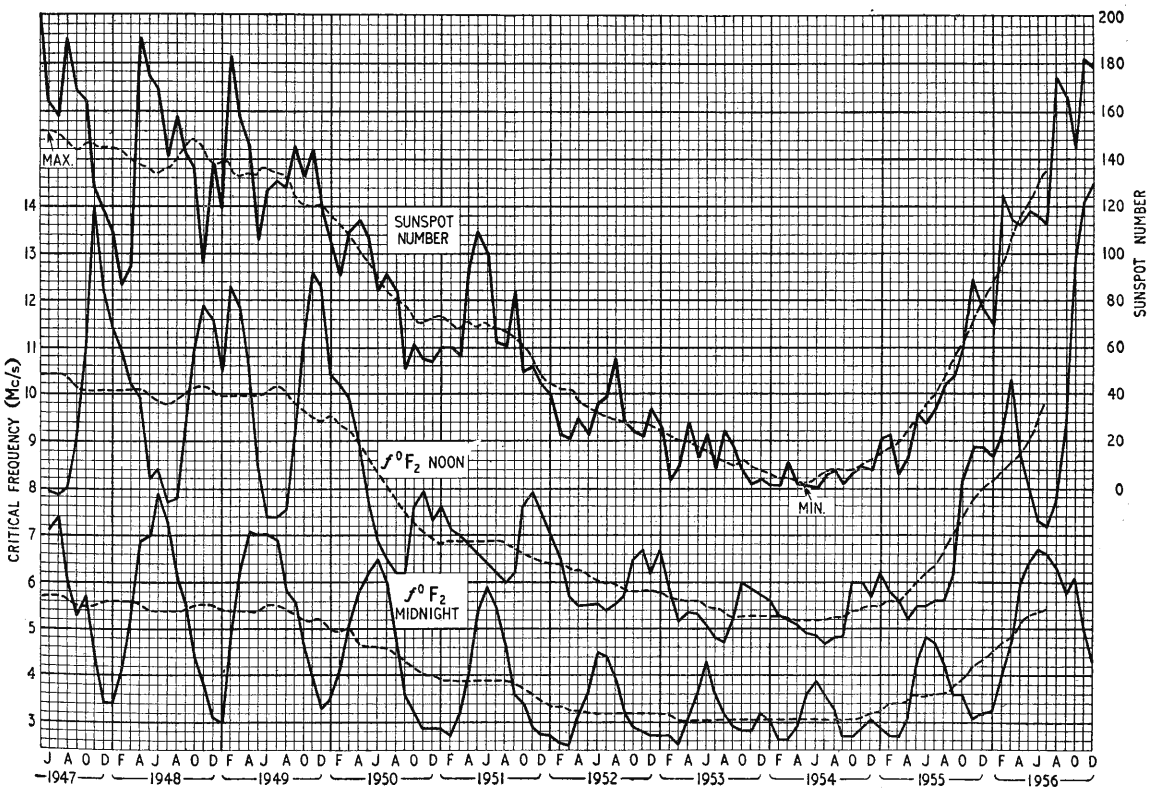
By T. W. BENNINGTON*

DURING 1956 the extremely rapid increase in solar activity, which had become apparent early in 1955, continued in its course. By the end of the year the activity had reached a level comparable with that recorded at the last sunspot maximum, in 1947. So far as radio propagation is concerned "quasi maximum" conditions may be said to have prevailed throughout most of the year, for from February onwards the daytime ionisation of the F_2 layer, over one or another part of the earth's surface, reached those high levels which render it capable of sustaining the propagation over long distances of frequencies well into the v.h.f. band. In fact the year must have been the record one for such propagation since high-frequency radio communication first began. During its last few months, frequencies of 50 Mc/s and higher, which hitherto have seldom been propagated to long distances, were being often so propagated at certain times of day. At the end of the year the solar activity was still increasing, though it now seems likely that the epoch of sunspot maximum is not far distant.

Course of the Sunspot Cycle.—The variations in the solar activity during the past few years, and their effects upon the F_2 layer ionisation, may be seen from the chart. The top full-line curve gives the monthly values of the sunspot number (the last twelve values are provisional numbers), and the *average* level of the sunspot activity is given by the top dotted line, which is a plot of the twelve-month running average of the monthly sunspot numbers.

The two lower full-line curves give respectively the monthly values of the F_2 layer critical frequency for noon and midnight, as measured at the D.S.I.R. ionospheric station at Slough. These curves exhibit large seasonal fluctuations, such that high noon values exist during winter with low values during summer, and high midnight values during summer with low values in winter. Superimposed upon the seasonal fluctuations is the long-period variation due to the changes in solar activity, and the two lower dotted lines, which give the twelve-month running average of the monthly values of noon and midnight critical frequency, illustrate this long-period variation clearly. They show a close correlation between the average level of solar activity and the average value of the F_2 layer critical frequencies, between which there is, in fact, an *approximately* linear relationship, at least up to a sunspot number of about 100. Since the

* The Research Department, British Broadcasting Corporation.



Course of sunspot cycle, with corresponding variations in ionospheric conditions throughout the period.

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maximum usable frequencies for long-distance communication are directly related to the F_2 layer critical frequencies, the former may be assumed to have a long-period variation approximately proportionate to that shown by the dotted lines, and correlated in a similar way with the variation in solar activity.

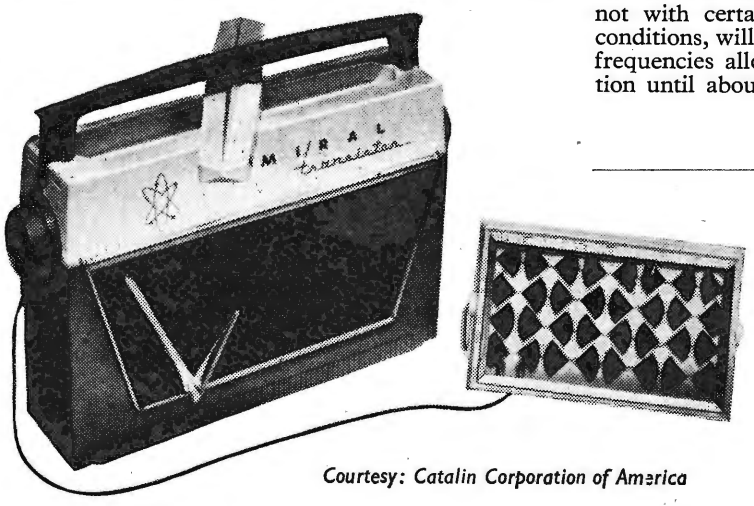
Highest Maximum Recorded.—From the sunspot maximum in May/June, 1947, to the minimum in April/May, 1954, there was a time lapse of 6.8 years, during which period the average sunspot number fell from about 152 to about 3, and the critical frequencies and m.u.fs. decreased by about 2 to 1 at the season and time of day when they are highest. Since the minimum only 2.7 years has elapsed, and during this short period the sunspot number has increased at a rate, which if maintained, points to a higher value being reached than at the last maximum. The average sunspot number (its exact value cannot yet be estimated) also appears to have reached a greater value than at the last maximum. Solar cycles with high maxima are, in fact, nearly always of a "sawtooth" shape, having a short increasing phase followed by a long decreasing one. In this respect they are quite unlike those with low maxima.

During 1956 there was a remarkably rapid increase in the average solar activity and in the average F_2 layer ionisation, and at the end of the year both were still increasing. The highest sunspot maximum so far recorded is that of 1778, when the average sunspot numoer was about 159. The coming maximum therefore promises to be the highest ever recorded, for it looks as if the 1778 value will almost certainly be exceeded. During 1957 solar activity may thus reach the highest level it has had for at least 208 years. Nevertheless, according to the astronomers, sunspot maximum is likely to occur early in 1957, perhaps as early as February. Thereafter solar activity will begin to decrease, though there may be large short-period fluctuations. The point is, though, that the *average* activity is likely to decrease at a far lesser rate than that at which it has lately been increasing.

Usable Frequencies.—During 1956 the usable band of frequencies for long distance communications was extended considerably at the high-frequency end. Throughout the year frequencies in the 26-Mc/s broadcast band were successfully used for long distance broadcasting and the 28-Mc/s amateur band was very frequently usable. During March U.S.A. police and business radio transmissions on frequencies up to 35 Mc/s were frequently received here, whilst the Channel 1 television signals from this country were being received regularly in various parts of southern Africa. During the summer there was, as usual, a considerable decrease in the occurrence of this v.h.f. reception, but towards autumn it was again renewed. During November and December U.S.A. business radio transmissions were receivable here almost daily on frequencies up to 43.5 Mc/s, the American amateurs on 50 Mc/s were very frequently heard and occasionally frequencies up to 57 Mc/s were propagated across the Atlantic. At this time the British Channel-1 television signals were being received in the U.S.A., and pictures, of a kind, were obtained, whilst, for the first time, the sound channel was received in Australia. These few cases of long-distance v.h.f. reception are cited as examples of the practical effects of the high level of F_2 layer ionisation, which is the result of the present high solar activity. They indicate that, under such conditions as now prevail, frequencies far exceeding those normally used for the purpose do become usable for long-distance communication over certain paths at the appropriate times of the day.

As for 1957 we may expect that, taking the year as a whole, there will be little alteration in the propagation conditions over the various paths as compared with the latter part of 1956.

About February the maximum daytime frequencies may be slightly higher even than those quoted above, and it may be that the sunspot maximum will occur during that month. But, since after that event the solar activity is likely to decrease quite slowly, the usable frequencies are likely to remain very high throughout the year. During the summer the daytime m.u.fs. (from this country) will, of course, decrease somewhat from the present values, but they will rise again to high values in the autumn. Highest night-time frequencies will be reached during the period May to August. And looking even further into the future we may anticipate, though not with certainty, that "quasi maximum" radio conditions, will permit the regular use of the highest frequencies allocated for long-distance communication until about the end of 1959.



Courtesy: Catalin Corporation of America

SUN-POWERED PORTABLE

POWER for this transistor portable, made by the Admiral Corporation of America, is supplied by 32 silicon junction photocells which are sufficiently sensitive to operate the receiver even on overcast days. Alternatively the set can be energized by 6 dry cells. The rotable rod aerial fits into a recess in the high-impact styrene moulded case.

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MARCH MEETINGS

LONDON

1st. R.S.G.B.—"Modern amateur communication receiver design" by R. G. Lane (G2BYA) at 6.30 at the I.E.E., Savoy Place, W.C.2.

4th. I.E.E.—"Electronics in administration—a survey" by Dr. D. C. Espley at 5.30 at Savoy Place, W.C.2.

7th. I.E.E.—"Cathodic protection" by L. B. Hobgen, K. A. Spencer and P. W. Heselgrave at 5.30 at Savoy Place, W.C.2.

7th. London U.H.F. Group.—Members' display of u.h.f. gear at 7.30 at the Bedford Corner Hotel, Bayley Street, W.C.1.

13th. Radar Association.—"The applications of radar techniques in science and industry" by Sir John Cockcroft at 7.30 at the Anatomy Theatre, University College, Gower Street, W.C.1.

15th. B.S.R.A.—"Ultra-linear amplifiers" by D. M. Leakey at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

15th. Television Society.—"Return of electrostatic focussing" by Dr. R. Pearce (E.M.I. Research) at 7.0 at 164, Shaftesbury Avenue, W.C.2.

20th. I.E.E.—"Recent developments in X-ray and electron microscopy with some applications to radio and electronics" by Dr. V. E. Cosslett and C. W. Oatley at 5.30 at Savoy Place, W.C.2.

20th. British Kinematograph Society.—"A new approach to telerecording" by A. E. Sarson and P. B. Stock with an introductory survey by L. C. Jesty at 7.15 at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2.

25th. I.E.E. (Students).—Address by Sir Gordon Radley, president, at 6.30 at Savoy Place, W.C.2.

27th. Brit. I.R.E.—"Disk recording" by Dr. G. F. Dutton at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

28th. Physical Society.—Annual general meeting of acoustics group and symposium on sound recording: "Factors limiting the performance of magnetic recording systems" by Dr. P. E. Axon, "Standardization of recording characteristics" by H. J. Houlgate, "Application of magnetic recording to computers and automation" by B. W. Pollard, and "Magnetic strip on cinematograph film" by J. Moir at 4.0 at the Royal Institute of British Architects, 66, Portland Place, W.1.

29th. Television Society.—"Studio production techniques" by Ian Atkins (B.B.C. Television) at 7.0 at 164, Shaftesbury Avenue, W.C.2.

BIRMINGHAM

25th. I.E.E.—"The B.B.C. sound broadcasting service on very-high frequencies" by E. W. Hayes and H. Page at 6.0 at the James Watt Memorial Institute, Great Charles Street.

CAMBRIDGE

5th. I.E.E.—"Cathodic protection" by L. B. Hobgen, K. A. Spencer and P. W. Heselgrave at 8.0 at the Cavendish Laboratory.

CARDIFF

11th. I.E.E.—"Transistor power amplifiers" by R. A. Hilbourne and D. D. Jones, and "Transistor d.c. convertors" by L. H. Light and P. M. Hooker at 6.0 at the South Wales Institute of Engineers, Park Place.

CHESTER

27th. Society of Instrument Technology.—"The future of semi-conductors in industry" by D. D. Jones (G.E.C. Research) at 7.0 at 5, King's Buildings, King Street.

EDINBURGH

15th. Brit. I.R.E.—"Applications of particle accelerators" by C. W. Miller at 7.0 at the Department of Natural Philosophy, University of Edinburgh.

FARNBOROUGH

27th. I.E.E.—"Frequency-modulation radar for use in the mercantile marine" by D. N. Keep at 7.30 at the R.A.E. Technical College.

GLASGOW

27th. I.E.E.—"The B.B.C. sound broadcasting service on very-high frequencies" by E. W. Hayes and H. Page at 7.0 at the Institution of Engineers and Shipbuilders, Elmbank Crescent.

LIVERPOOL

4th. I.E.E.—"Electronics and automation: some industrial applications" by Dr. H. A. Thomas at 6.30 at the Liverpool Royal Institution, Colquitt Street.

6th. Brit. I.R.E.—"The preparation of service and technical data sheets" by E. A. W. Spreadbury (*Wireless Trader*) at 7.0 at the Chamber of Commerce, 1, Old Hall Street.

MALVERN

11th. I.E.E.—"Vacuum techniques" by D. J. Taylor, "Temperature control" by J. P. King, and "Cutting of semi-conductors" by J. R. Walford at 6.0 at the Winter Gardens.

MANCHESTER

7th. Brit. I.R.E.—"Electronic musical instruments" by A. Douglas at 6.30 at the Reynolds Hall, College of Technology, Sackville Street.

13th. I.E.E.—"The electronic age" by Dr. R. C. G. Williams at 6.45 at the Engineers' Club, Albert Square.

NEWCASTLE-ON-TYNE

4th. I.E.E.—"An experimental study of high-permeability nickel-iron alloys" by C. E. Richards, E. V. Walker and A. C. Lynch at 6.15 at King's College.

PORTSMOUTH

6th. I.E.E.—"Germanium and silicon power rectifiers" by T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell at 6.30 at the Central Electricity Authority, 111, High Street.

29th. B.S.R.A.—"Hearing aids and audiometers" by S. Kelly at 7.15 at the Central Library.

READING

18th. I.E.E.—"The transatlantic telephone cable" by R. J. Halsey at 7.15 at the George Hotel, King Street.

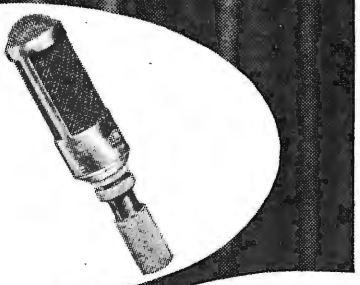
RUGBY

12th. I.E.E.—"Ferrites" by Profesor F. Brailsford at 6.30 at the Rugby College of Technology and Arts.

WEYMOUTH

1st. I.E.E.—"Analogue Computors" by R. Postlethwaite at 6.30 at the South Dorset Technical College.

TRIX
SOUND EQUIPMENT



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RANDOM RADIATIONS

By "DIALLIST"

No, No, Sir!

"CATHODE RAY" was considerably off the rails in his mild criticism of my use of monochrome as an alternative to black-and-white in describing the television picture. White, he suggests, is as far removed as it could be from monochrome, since it is a combination of all the colours of the spectrum. True; but if he'd thought for a moment, he'd have realized that the television "white" isn't white, but a very pale grey. The dictionary defines the word monochrome as referring to a representation or image in different tints of the same colour. The television picture exactly fits in with this, for it consists of nothing but greys, from the very pale to the very dark. As for his suggested alternative, "panchrome," words fail me, as I'm sure they do my *confrère* "Free Grid." "Pantochrome," if you like, "C.R.", but not such a verbal monstrosity as panchrome. Yes, I know there's a photographic term panchromatic; but that must have been coined by some fellow with "little Latin and less Greek."

Projection v Large Tube

A READER takes me to task for having said in these notes that a projected television picture is less obviously liney than that on the screen of a large cathode-ray tube. The number of scanning lines, he points out, is precisely the same in both instances. True enough, but, am I not right in saying that on the very small tube of a projection receiver the spot, no matter how sharply you focus it, is relatively a good deal larger than that painting the pictures directly on the screen of a 17-inch or 21-inch tube? Hence, if there are any gaps between the lines of an interlaced scan, they are narrower and less noticeable than those on the screen of a big-tube, direct-viewing receiver. Though he doesn't appear to realize it, my correspondent himself proves the truth of my contention. His projection set, he writes, gives a 36×27-inch picture and he and his wife sit 10 to 12 feet from the screen. Now, a useful rule of thumb for direct viewing is that, without spot-wobble, the minimum viewing distance in feet is just about half the size in inches of the c.r.t., say, 10 feet for a 21-inch tube. Well, my correspondent and his wife are sitting at about that distance from a projected picture more than twice the size of the image on a 21-inch tube and having no bother with lininess. To give a direct picture of the same size you'd need a 42-in c.r.t. (!) and would have to sit over 20 feet from it to get rid of the lines.

A Marine Radar Point

"DEAR Mr. Diallist," wrote a Birmingham reader, "weren't your radiations a little more random than usual when you wrote recently [December issue] of the need for a radar predictor?" He goes on to point out that if the bearing of another ship remains constant while the range decreases, you are on a collision course. Everyone who's had anything to do with marine radar knows that, for it's one of the basic rules. The trouble is that if officers don't plot it isn't always realized that the bearing is staying put and the range shortening. And this is particularly true when one or both ships make changes in course and speed. I remember attending one court case in which that's exactly what happened. Only one ship had radar. No plotting was done; but every order given by the navigating officer made a collision more and more inevitable. And this on the open sea and the "blip" of the victim first seen on the radar screen when the range was the best part of ten miles!

Television in France

YOU may recall that in the last issue I expressed surprise at the distribution of French TV stations. They seemed, according to the map in the December issue, to be mainly concentrated on the north coast and round the northern and eastern frontiers. Hardly had my copy gone to the printer when the post brought me from Paris the January issue of that excellent magazine *Télévision*. On its cover is a map showing the layout of the French television system as it will be when the nation-wide plan, now well under way, is completed. It can't have been an easy task to devise a scheme for the TV coverage of the whole of France, for considerable parts of the country are mountainous and therefore "difficult," and, due to the bandwidth needed by the French system, only twelve channels are available in Bands I and III. As it now stands, the scheme is most ingenious. Amongst the big problems to be solved were those of inter-station interference, of blind spots and of a vast network of cable and radio links. Directional aerials will be used for at least 16 of the main stations so as to

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give a strong signal where it is wanted. The blind spots will be catered for by low-powered satellites or relays.

A Four-year Plan

Altogether 40 main stations are to be used, of which 17 will have an e.r.p. of 100 kW or more, in certain directions at any rate. Thirteen of these are rated at 200 kW and two at 300 kW. At least 20 main stations will be on the air by the end of this year, and the whole scheme completed by 1960. It's a bold step, for so far television sets have been slow in making their way into French households. The R.T.F. firmly believes—and I'm sure they're right—that there will be a snowball increase in the number of domestic TV receivers as more and more transmitters come into action. French television certainly deserves to succeed, for the courageous decision some years ago to adopt the 819-line standard means that France has potentially the best television pictures in the world to-day. Our own Television Advisory Committee originally had in mind that some similar standard should eventually come into use here; if you remember, they recommended years ago that research should go forward with a view to developing a system of the order of 1,000 lines. A pity that so far it hasn't come to anything and doesn't look like doing so.

A Question of Efficiency

HAVE you ever thought what hopelessly inefficient pieces of apparatus domestic sound and television receivers are from one point of view? The average mains-operated sound set needs about 30 watts input to its l.t. and h.t. circuits to produce an output of some 2 watts from its final a.f. stage. The ratio is better in battery sets. For television receivers the average input from the mains is some 150 watts for an audio output of 2-3 watts, and no great amount of power from the line-scan, frame-scan and e.h.t. circuits. What an improvement there'll be in a few years' time, when transistors come into more general use. Sooner or later, I suppose, sets drawing their power from the transmitter will be common in primary service areas. I hardly think that even now "Free Grid" need fear being run in for stealing electricity, the property of the B.B.C. What you have broadcast is surely no longer your property. Haven't you made a gift of it to anyone licensed to receive it?

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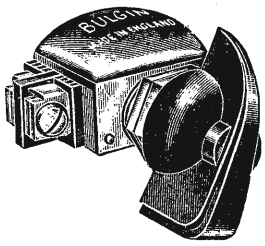

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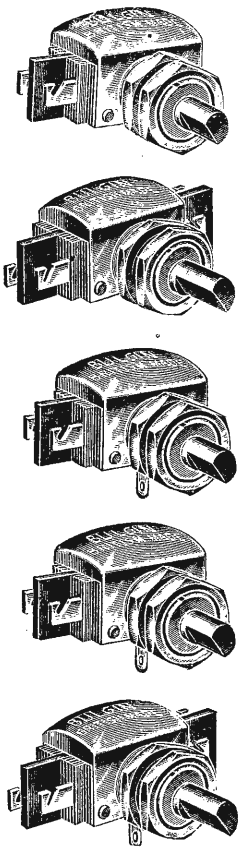

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UNBIASED

By FREE GRID

Electronic Torsothermer

ONE of the gossip-column writers of an evening newspaper has just discovered the principles of electronic cooking which was first dealt with in these columns and elsewhere many years ago. This particular writer has just heard of the invention from New York and has given his readers all the usual wonders about the ability of an electronic oven to cook the inside of a cake without burning to a cinder the outside.

Well, there is nothing new in that to readers of *Wireless World* but it has set me thinking about a problem of my own. For many years I have used an electric blanket. I have no complaints about it except that it is unnatural as it warms my outside and the heat then travels inwards. When I eat food it generates heat inside me and this heat travels outwards. By means of electronic cooking technique surely it would be possible for me to warm myself in the same manner as nature does it. To do the whole thing electronically, instead of merely electrically as I do at present, would, of course, give me great psychological satisfaction.

The only thing is that my knowledge of the techniques of electronic heating and cooking is rather slender, and I am not at all sure how to set to work with safety. As you will appreciate, an error whereby, say, the liver was raised to an inordinately high temperature might be fraught with serious medical consequences. If any of you have any real knowledge about this matter I shall be very glad to hear from you. This is, of course, really a question for electro-physiologists and maybe a paper on the subject has been presented at a meeting of the Electro-Physiological Technologists' Association.

Antenna in Excelsis

I SEE that Dr. R. S. Scorer recently told the Minister of Power that in his view domestic chimneys are responsible for far more pollution than a lofty factory chimney. One factory chimney will, of course, discharge far more smoke and other harmful substances than a domestic chimney and so to make a fair comparison several of the latter should be taken into account so that they are together discharging the same quantity of smoke as the factory chimney. Even so the factory chimney will do far less damage as, owing to its greater height, it disperses its noxious substances over a far greater area than do the domestic chimneys; in other words, the concentration is less.

Surely the logical theory to follow would be to make domestic chimneys illegal? A tall, factory-type chimney could be erected at the end of each road. To this chimney all domestic smoke could be fed by special underground ducts using forced draught.

This would at once make possible my favourite idea of a communal TV aerial for each road. The tall communal "factory" chimney would be an ideal site for it. Not only would its great height enable TV range to be greatly increased, but whole masses of unsightly roof aerials would be wiped away; indeed, the very disappearance of domestic chimneys would *literally* undermine the very foundations of our present aerial eyesores.

If any of you cavil at the ugliness of a factory chimney at the end of each road, I would point out that with proper architectural design it could be as graceful as the tall and slender campanile of Westminster Cathedral.

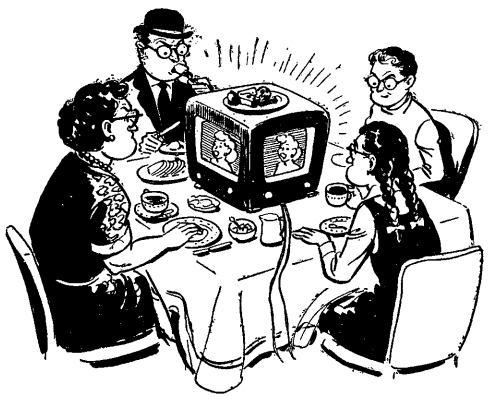
Eupeptovision

MANUFACTURERS of television sets in this country don't seem to have made any provision to enable their customers to view continuously throughout the evening now that the hour's interval between 6 p.m. and 7 p.m. has disappeared. All of us, no matter whether we belong to the U or non-U sections of the community, have hitherto been able to use that interval to snatch a hurried meal.

Now, of course, we eat and view simultaneously. What is needed is a set with four faces like Big Ben to "cover" each of the four sides of a dining table so that all members of the family can eat while they view. I have hastily knocked up a table set of this eat-while-you-view type and it is so successful that I should like manufacturers to make a similar type available to everybody.

But the four faces should not merely be paralleled up. Each tube should be independent and switchable to the B.B.C. or I.T.A. to cater for the differing tastes of various members of the family. In case any of you are asking, "But what about the sound for each service?" I would add that this can be easily catered for by the use of hearing-aid-type earpieces.

One of the greatest advantages I have derived from my own E.W.Y.V. set is that it checks any tendency for me to bolt my food in order to get back to the television programme. Thus it is greatly conducive to eupepsia.



My E.W.Y.V. receiver.

An Electronic Miss Smith

SOME years ago I had a few words to say about the sad day in the future when all the fair Miss Smiths in our offices will be replaced by electronic typewriters. That day is a lot nearer now judging by an article I have been reading about the research work that is being done in various parts of the world and more particularly at University College, London.

The monstrous machine which is being developed there has, so far, a vocabulary of only 140 words and it spells them in a manner not found in the O.E.D. In these respects it is, therefore, not unlike the dumb blondes which grace, or disgrace, some offices.

Another point of similarity between this machine and its human counterpart is that it gives of its best only when working for one particular person. In the machine, the reason is that it responds best to the particular type of pronunciation for which it has been developed; but with the ladies, there are other considerations.

However, nothing will induce me to persuade my directors to invest in one of these contraptions until it reaches the stage when it can take over *all* the duties of our deft-fingered dactylographers who, metaphorically speaking, smooth our brows and bring a humanizing influence into the soulless cathedrals of commerce.

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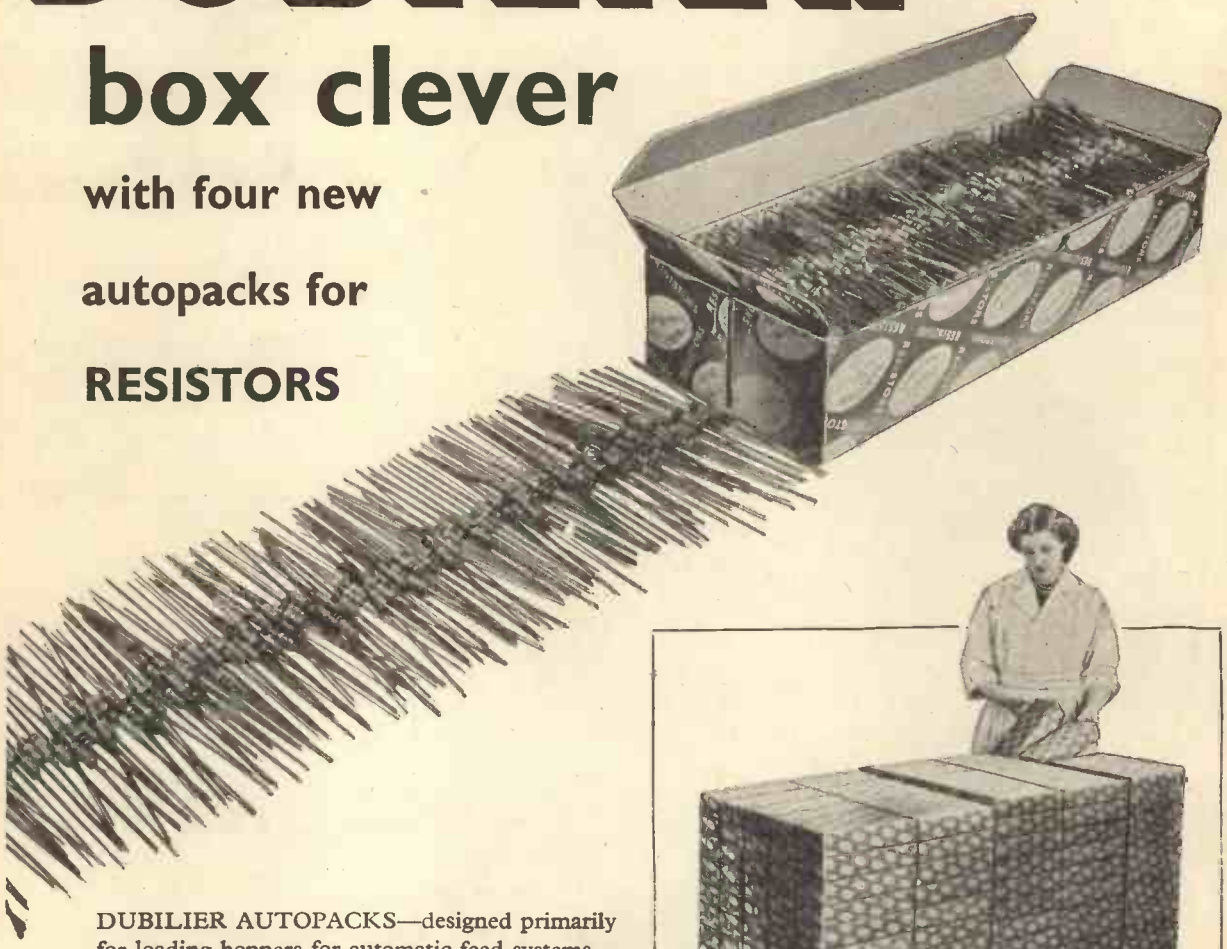
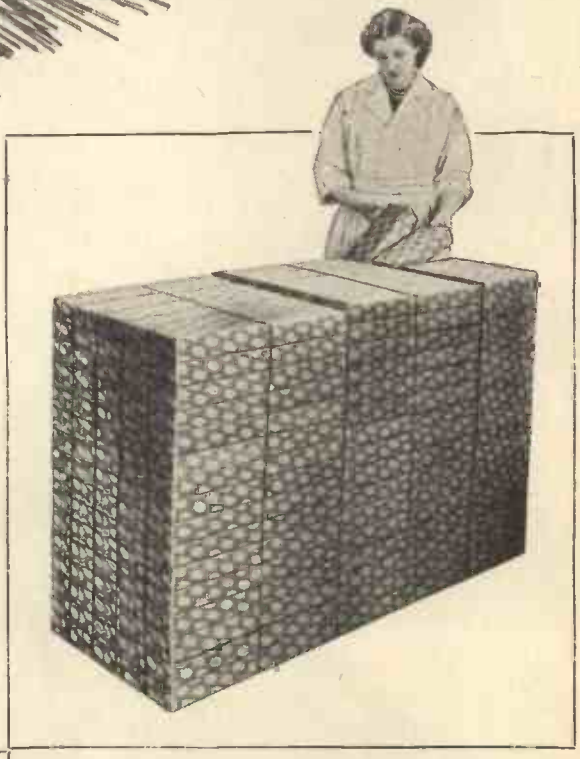
DUBILIER

box clever

with four new autopacks for RESISTORS





DUBILIER AUTOPACKS—designed primarily for loading hoppers for automatic feed systems—also solve the spiky problem of resistor storage. The resistors* are housed in packs of 50, 100, 500 and 2,500 for type BTS, and in packs of 100 and 500 for type BTB—all lined up with connecting wires dead straight, ready for immediate use—and taking up very little space in the process. The large *and* the small user would be well advised to take stock of these handy, space and time-saving packs.

50

100

500

2500

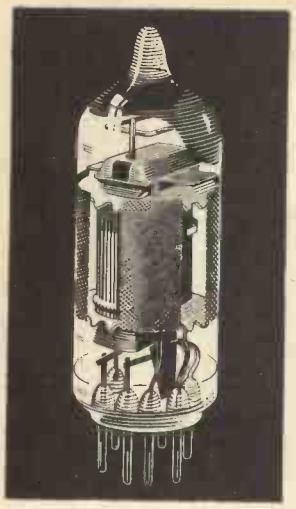
No storage problems here!

This modest sized stack contains no fewer than one million separate resistors. A pack of 50 would occupy no more room than 10 cigarettes on the workbench. Whether you use resistors in tens, hundreds or thousands—see Dubilier about these new space-saving Autopacks today.

**The resistors are available in two ratings: BTS ½ watt, BTB 1 watt at 70°C. Resistance range is 100 ohms to 10 megohms (BTS) and 390 ohms to 22 megohms (BTB). Each type is completely protected by a phenolic resin housing which is sealed at the ends.*

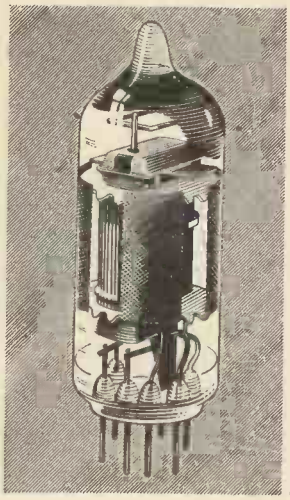
DUBILIER CONDENSER CO. (1925) LTD., Ducon Works, Victoria Rd., North Acton, W.3. Phone: ACOrn 2241. Grams: Hivoltcon, Wesphone, London

DN 173A



SPECIAL QUALITY VALVES

and special quality valves



. . . there is a difference

Mullard Special Quality valves can be supplied in accordance with various standards of reliability including, for instance, the full British Government CV4000 specification and the American MIL specifications. An economical choice of types is therefore available for equipment designers to satisfy particular standards of reliability which would include future NATO requirements.

Mullard achievement in the production of Special Quality valves to defined standards is indicated by the fact that Government establishments have already been supplied with many hundreds of thousands of Mullard valves to the rigorous and complicated full CV4000 specification.

Details of the range of Mullard Special Quality valves for military and industrial applications are available from the address below. Assistance in selecting the most suitable types for particular applications may also be obtained from the Technical Advisory Service at the same address.

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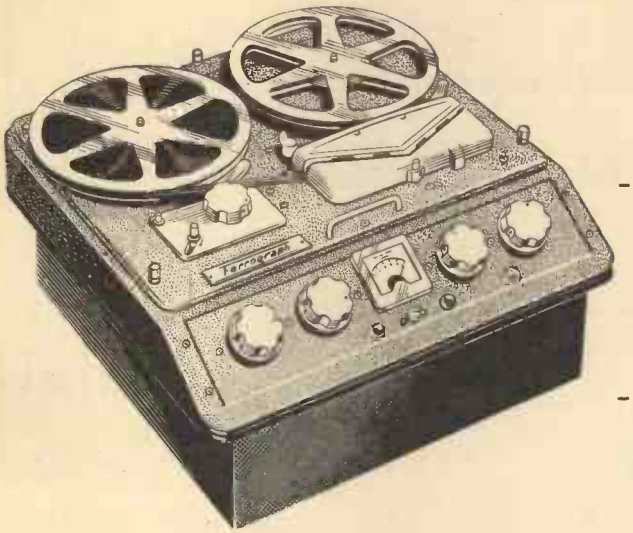
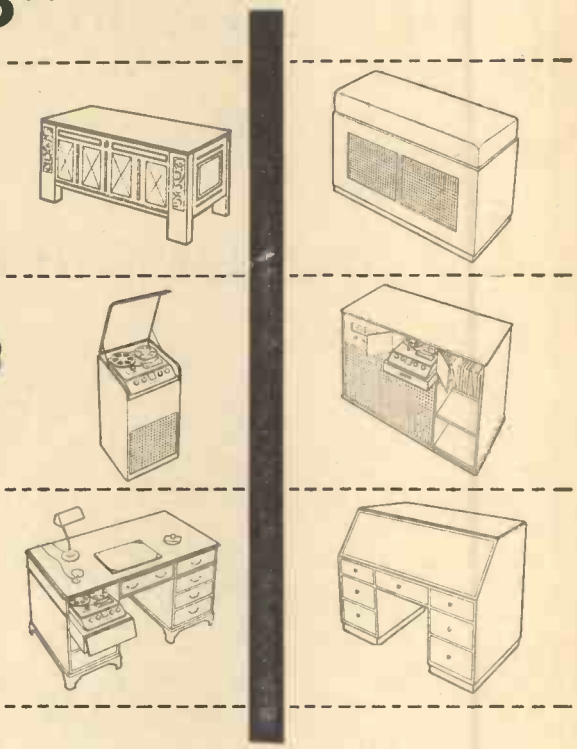
Six cabinet ideas for the Ferrograph "66"





Portability in a Tape Recorder isn't always an advantage. On the contrary, it can prove a costly handicap if valuable — and often irreplaceable — recording opportunities are lost because the instrument is not set up for immediate use. Hence the rapidly growing popularity of this new Ferrograph unit designed for use with an external loud speaker system.

When the Ferrograph 66 is given a worthy home in a piece of furniture to match its surroundings it becomes the last word in home entertainment. For with it can be permanently associated an F.M. Tuner and a Gramophone Turntable. This arrangement not only permits tape recordings of the highest quality to be made from radio, disc or microphone at the turn of a switch, but the owner can use the high fidelity amplifier incorporated in the base of the Ferrograph with the F.M. Tuner as a superb radio receiver or with the Turntable as a luxury gramophone. He has, in fact, acquired three instruments in one at a very substantial saving in space and cost.

All metal construction, with overlap to fit snugly on any flat surface with opening 15⅜" x 16½". Incorporating all Ferrograph proved features of design, including synchronous capstan motor, playback tone controls, two speeds, 2½ watts undistorted output, source selection switch, automatic motor cut-off. Finished in gold bronze with cream knobs and accessories.

Model 66N	Model 66H
3¾" & 7½" p.s.	7½" & 15" p.s.
84 gns	**88 gns**

(including 1,750 ft. Ferrotape on 8¼" reel)

The Incomparable **Ferrograph "66"**

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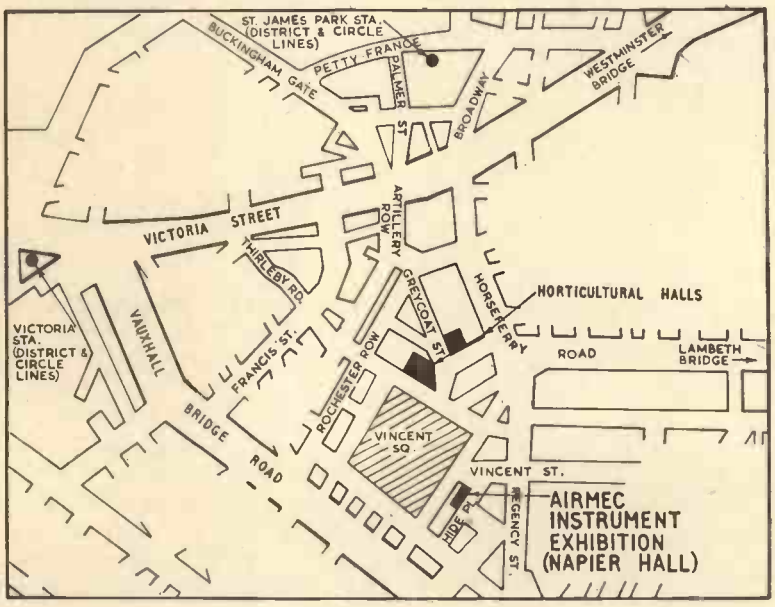

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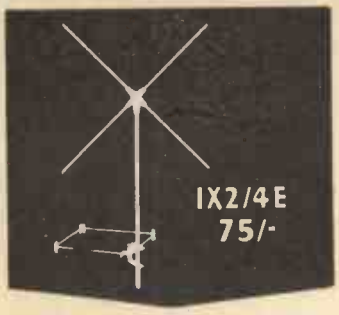


BAND I

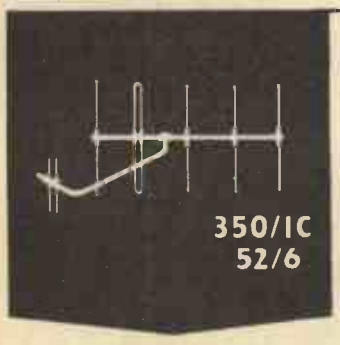
BAND I

A complete range of Antex (illustrated) Dipole, 'H', Fringe and Indoor models is available. Outdoor models can easily be adapted for Band III by adding Band III Grip-on aerials as 350/1C below.

BAND II

BAND II

Indoor and outdoor models to suit all conditions and to provide the very best results for VHF/FM equipment. Models for fitting to existing TV masts are available.



BAND III

BAND III

3, 5, 8, 10 element and Stacked Arrays for outdoor installation and a comprehensive range of indoor models.

HILO

HILO

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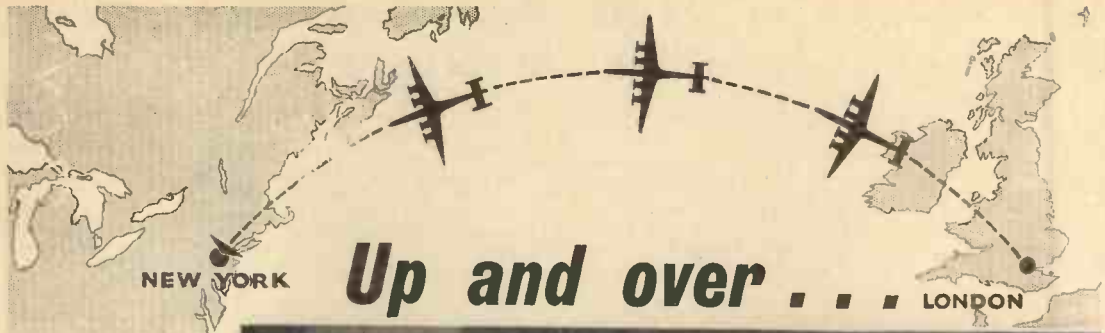

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The Monarch has established itself as a top favourite in the hard-to-win American market—radiogram manufacturers there have geared production to meet the increasing demand for the U.A.8. When the tight delivery schedule was threatened by the New York dock strike the problem was tackled in the grand manner—a manner worthy of the Monarch—we made air transport history! Constellations were chartered and loaded exclusively with Monarchs, these dollar-earners flew the Atlantic TONS AT A TIME AND our American friends shared the cost.

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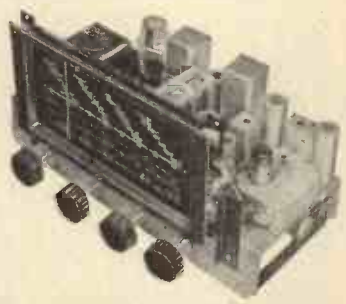

"SYMPHONY" AM/FM RADIOGRAM CHASSIS Mk II Very high grade Radiogram Chassis incorporating the Long, Medium, Short and VHF Bands; nine valves including new fan-type, built-in Magic Eye; push-pull output for high quality reproduction. Input sensitivity adequate for Studio. Professional quality (P) and transcription (PX) pick-up cartridges. New type ultra-sensitive, anti-radiator, no-drift F.M. front-end; built-in ferrite rod A.M. aerial; plug-in F.M. indoor dipole aerial supplied free. Negative feedback; 15 ohms tapped 3 ohms output, entirely new-look German-type dial and knobs in gold, brown and cream, measuring 15in. x 6in. horizontally. Depth front to back 8in. An extremely attractive up-to-the-minute instrument. Price complete with 10in. Goodmans Loudspeaker. **26 gns.** plus carriage 10/-. Alternatively, allowance made on standard Speaker against a more expensive, high fidelity speaker. Delivery from stock.

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LENCO GL55, as above but without pickup and autostop but fitted with Special Device for Groove Location and knob which completely disengages drive-wheel. Suitable for use with any pickup, especially transcription types and B.J. Arm. Price **£17/10/4.** Immediate delivery guaranteed.

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CONSOLE AMPLIFIER CABINETS. 33in. high, lift-up lid with piano hinge, take Tape Deck, Gram Unit or Autochanger, Amplifier, Pre-Amplifier, and Radio Feeder Unit, finished medium walnut veneer. De luxe version, price 12 gns. Oak or mahogany veneers and special finishes to order. Carriage according to area. We will quote by return.

NORDYK CABINETS. Speaker Enclosure **£5/17/6.** Table Model Amplifier/Gram Unit Cabinet **£5/19/6.** Table Model Tape Recorder, Tape Amplifier or Radio Tuner Cabinet **£5/19/6.** Record Storage Cabinet holding 150 records **£4/17/6.** All above cabinets measure (internally) 19in. wide x 13in. high x 13in. deep and finished in polished walnut, thus enabling a complete installation to be built up unit by unit in matching style cabinets and added to as required. We can supply Amplifiers, Tuners, Gram units, Tape Decks and speakers mounted in these cabinets. Examples on demonstration.

TAPE RECORDER DEPT. We are specialists in the supply of tape gear for use in conjunction with High Fidelity Equipment. We are familiar with all worth-while Tape Recorders and Decks on the market and are in a unique position to advise on Tape Recorders, Tape Decks, Tape Amplifiers and Tape Pre-Amplifiers and give unbiased opinions and demonstrations. All those intending buying a Tape Recorder or adding Tape facilities to their present systems are advised to consult us before spending money, as we might well be able to save you money and dissatisfaction. Call for a demonstration, or write.

THE "SYMPHONY" DE-LUXE TAPE RECORDER. 2-speed, twin-track, microphone, radio and gramophone inputs. Facilities for playback through high quality internal elliptical speaker or through external high fidelity speaker or through external high fidelity amplifier. Automatic head demagnetisation Wide frequency range heads. Housed in handsome polished walnut cabinet. Fantastic value for money at 49 gns. or 9 monthly payments of 6 gns. Also available with built-in revolution counter for 52 gns. or 9 monthly payments of £6/13/-. Recommended microphones Acos £3/8/- or Lustraphone, 3 gns. Plus carr. and pkg. **£1.** Full details in catalogue.

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Please send me Newnes RADIO AND TELEVISION SERVICING without obligation to purchase. I will either return the work within eight days or I will send the first payment of 12s. 6d. eight days after delivery, and you will then send me the HANDY ENLARGER. Thereafter I will send 10s. 0d. monthly until £9 12s. 6d. has been paid. Cash price within eight days is £9 5s. 0d.

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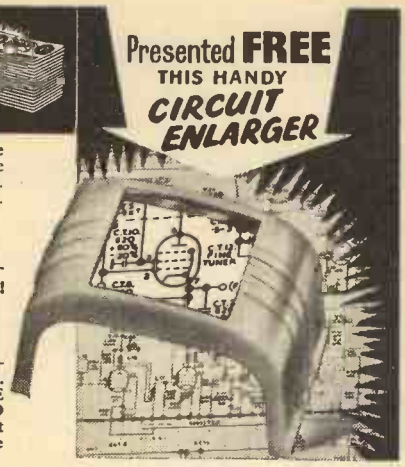

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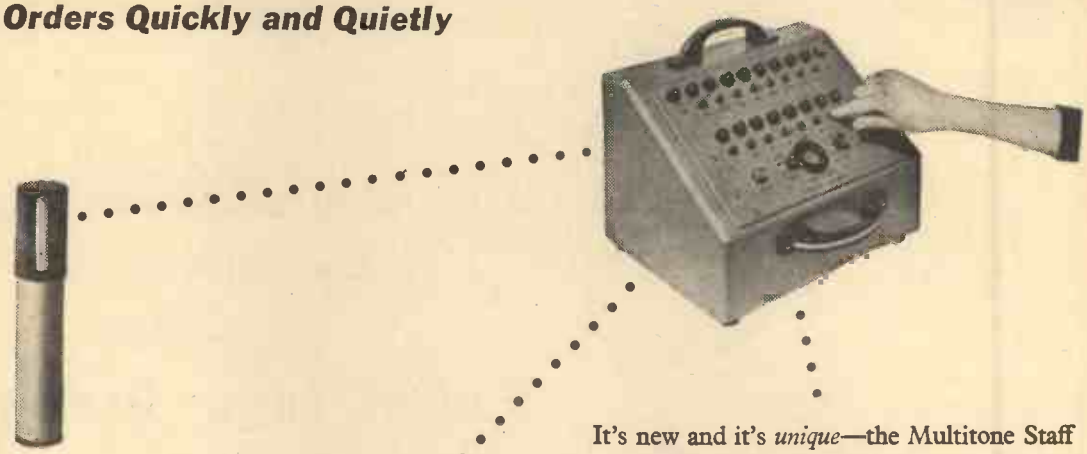

It's new and it's *unique*—the Multitone Staff Location System. There've been loudspeakers, bells, lights and even buzzers, but not a system in which confidential messages can be delivered to individual members of a staff—whether numbered in tens or hundreds. However compact or scattered an organisation may be, this is going to be the biggest business time-saver yet. Originally developed in conjunction with St. Thomas' Hospital, this system is now far in advance of anything yet made and is sold at a highly competitive price!

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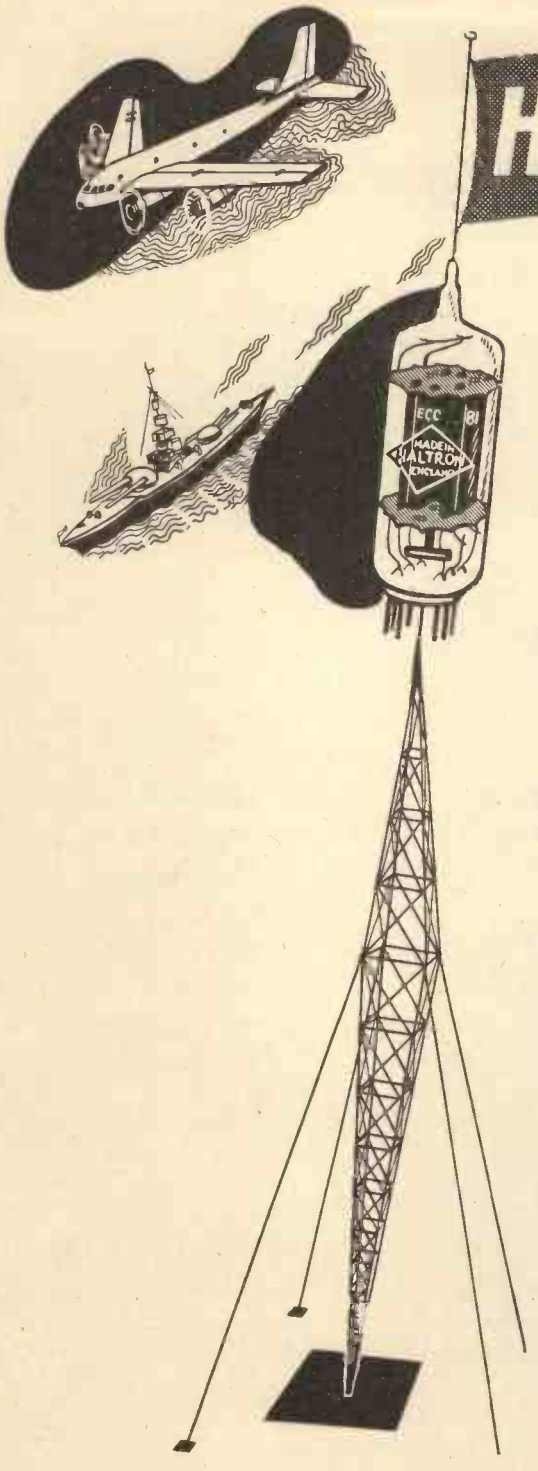

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Build these 2 useful instruments from

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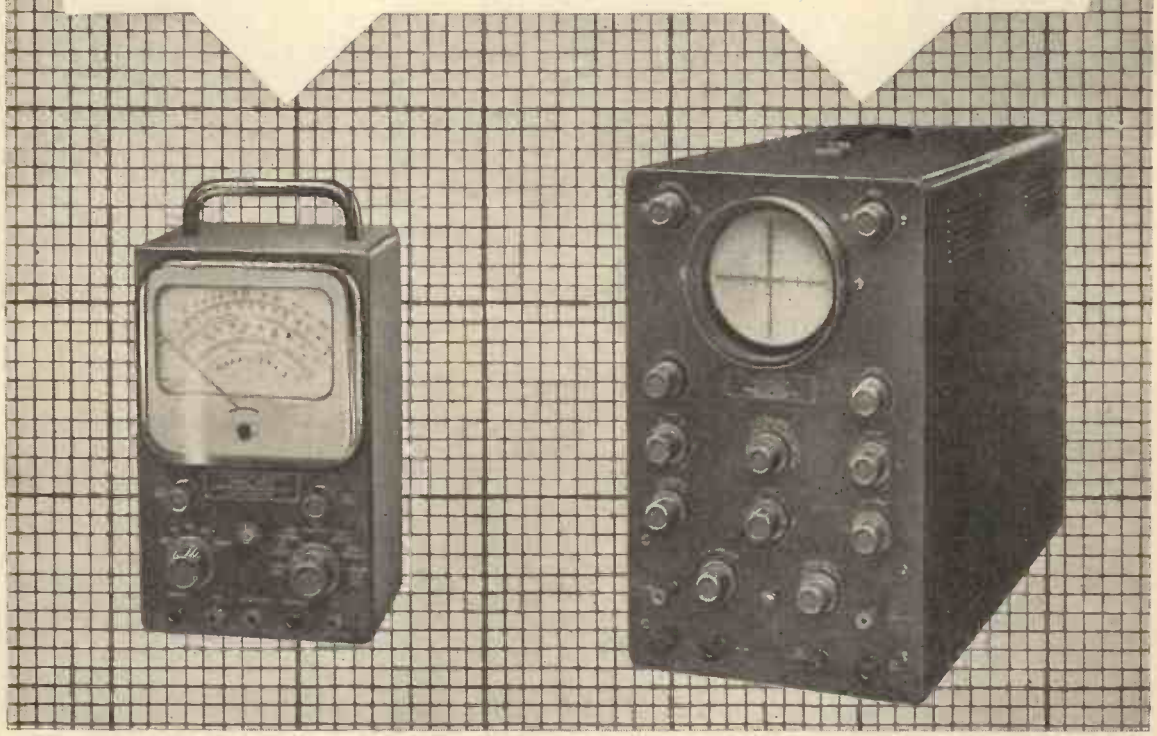

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can supply special test sets for F.M. Mobile Radio

Type TF 1064

Signal Generator Type TF 1064
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Type TF 1065

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Signal Generator TF 1064 provides r.f. outputs — f.m. or a.m. — in the ranges 68 to 174 and 450 to 470 Mc/s, i.f. outputs at five spot frequencies, and also an a.f. output.

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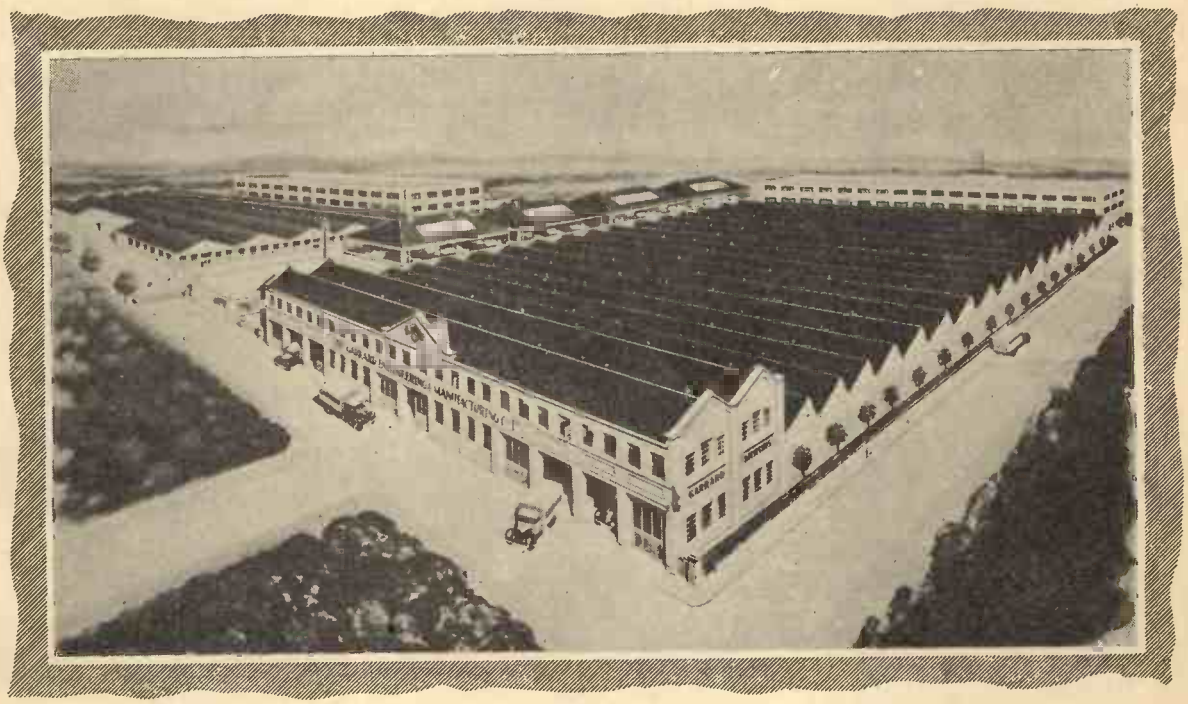

"Why GARRARD *is best" series No. 1*

This is the main Garrard Factory (there are also three others) in which is installed the finest engineering equipment for producing Garrard gramophone reproducing equipment.

This modern plant combined with the finest British craftsmanship is the reason why Garrard products are known throughout the world for their high standard of quality and reliability.

Subsequent advertisements will describe some of the operations used in producing the world's finest gramophone record reproducing equipment.

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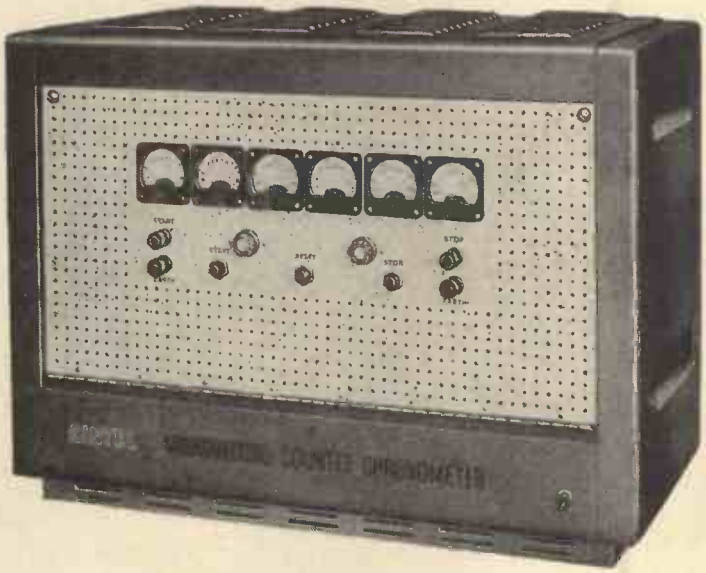

This equipment is designed to measure small intervals of time to a high order of accuracy and two ranges are provided:

(1) 1 μsec. to 1 sec. in steps of 1 μsec.

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Accuracy of each range is better than ± 0.005% ± the step interval.

Full details on this and other 'Cintel' Chronometers are available on request.

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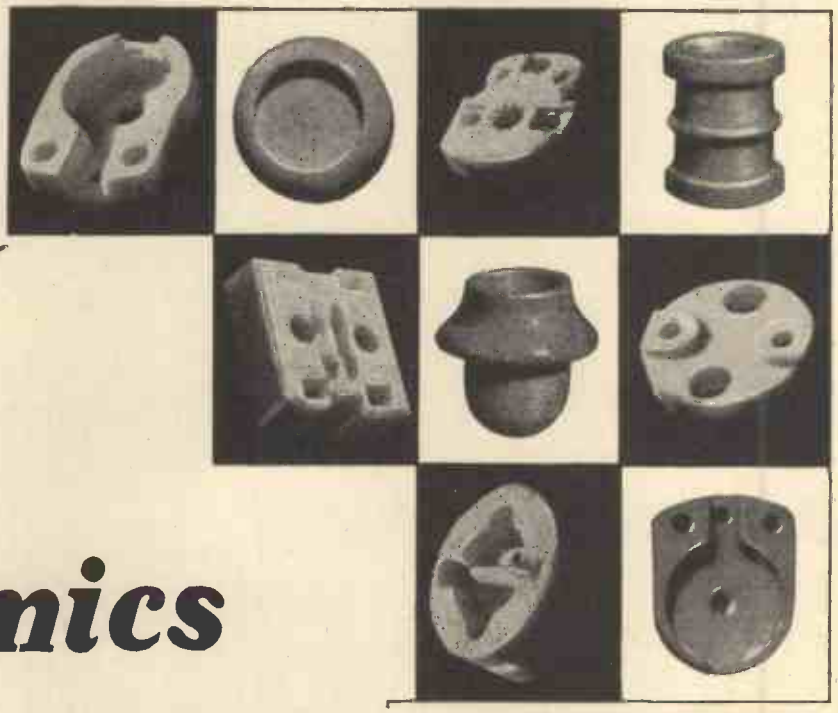

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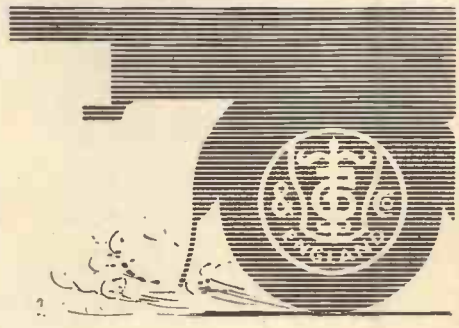

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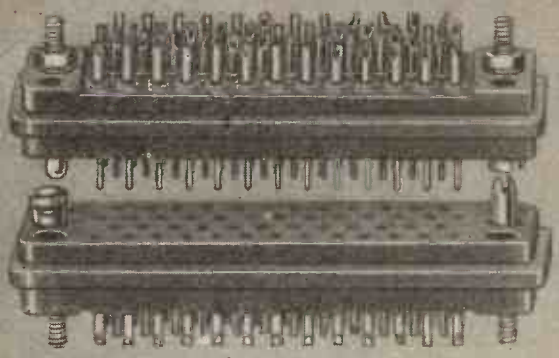

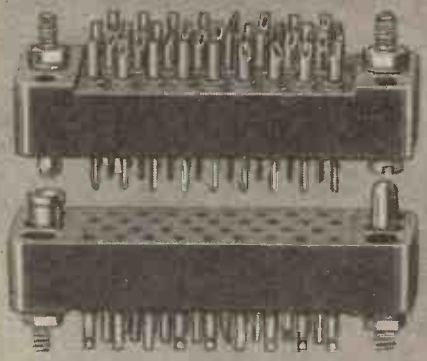

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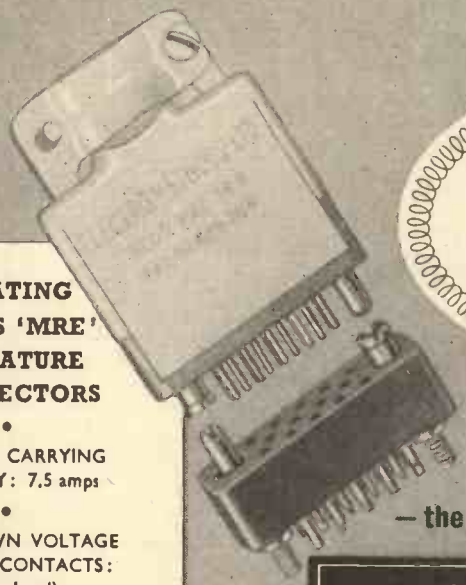

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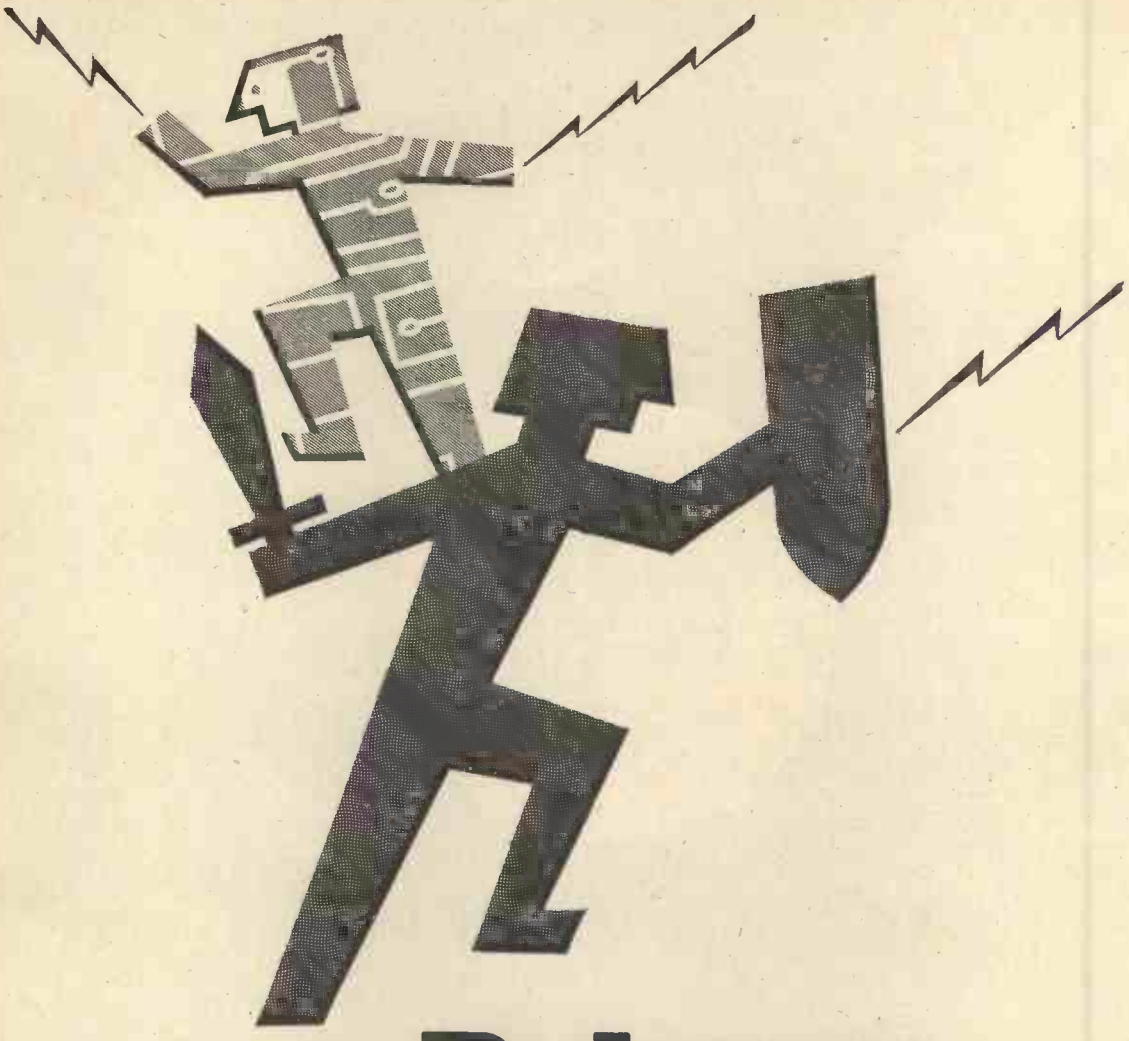

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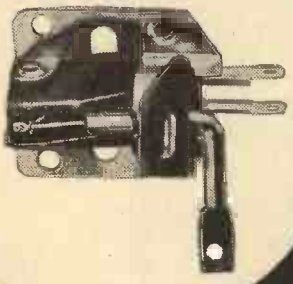
You should use DELARON laminates.

For information, advice and service get in touch with *Dept. D8F, Thomas De La Rue & Co Ltd* 84-86 *Regent Street, London, W1.*

DELARON' is a registered trade mark

This is the way to play it



All the recorded sound — that's the way the 'Sonotone' equipped radiogramophone will play it! The revolutionary 'Sonotone' pick-up head — a superior, highly sensitive product — represents the first basic improvement in sound head technique for a decade. It is completely humidity and temperature proof, produces no magnetic hum and has a great many other technical advantages which are discussed fully in T.C.L. publication No. 102. Design Engineers are invited to ask for a copy and for any further technical information they may require.

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by Advance

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type **74**

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—moulded track potentiometers by **Plessey**

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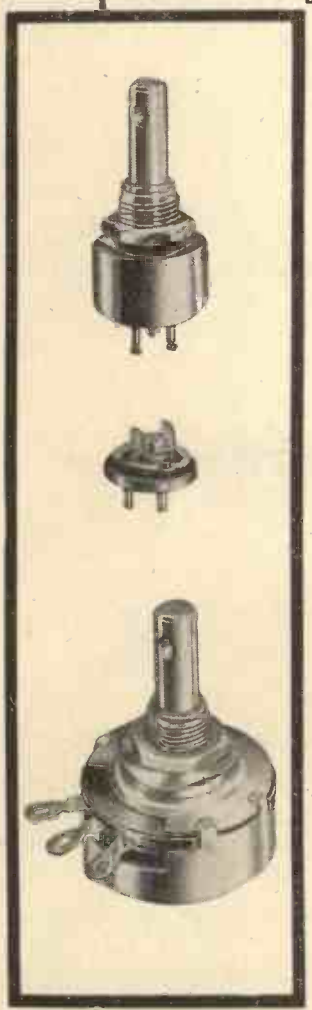


DURABLE

The outstanding reliability of these potentiometers is a tribute to the Plessey Research and Development engineers whose efforts to meet the stringent Services requirements and the critical demands of the Commercial market have resulted in products of superior design and function.

Miniature Type M H 2

A high quality potentiometer for commercial laboratory and Services application. Services Specification RCS122. The standard version is fitted with spindle and panel humidity seals.

GENERAL SPECIFICATION

Rating: ambient 70°C	$\frac{1}{4}$ watt
Temperature Cat.	40/70°C
Humidity Class	H2
Minimum Resistance	50 ohms max.
Overall Diameter	23/32 in.
Overall depth of control from mounting face, including tags	$\frac{5}{8}$ in.

Sub Miniature Type G

Type Approved to Certificate No. 974 Issue 1, Ref. TA1373, this pre-set, open-type control is of particular interest to industrial communication and Service equipment manufacturers.

GENERAL SPECIFICATION

Range Linear ±20%	1,000 ohms to 2 megohms
Rating: ambient 70°C	$\frac{1}{4}$ watt total track rating
Minimum Resistance	50 ohms max.

Spindle and Panel Sealed Type E H 2

For military and para-military applications, this control is particularly resistant to conditions of extreme humidity.
Type Approved to Certificate No. 906, Issue 2, Ref. TA1230.

GENERAL SPECIFICATION

Rating: ambient 100°C	1 watt
Temperature Cat.	40/100°C
Voltage Limitation	500V
Humidity Class	H2
Minimum Resistance	50 ohms max.
Overall Diameter	1-5/32 in.
Overall depth of control from mounting face	21/32 in.

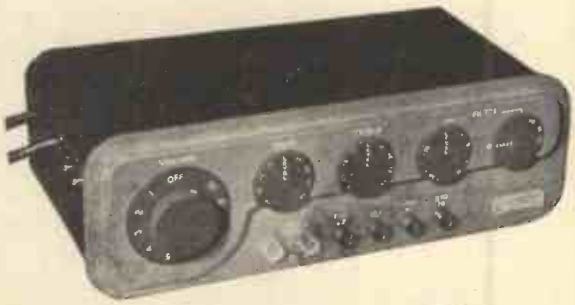
THE PLESSEY COMPANY LIMITED · KEMBREY STREET · SWINDON · WILTS

PS1

for the closest approach to the original sound

THE criterion, as always, is that the reproduced sound shall be the closest approach to the original—that the enjoyment and appreciation of music may be unimpeded. This is reflected throughout the design of the QUAD II. It is reflected, too, in the straight-forward and logical system of control, achieved without the sacrifice of a single refinement or adjustment capable of contributing to the final objective.

Send for further details and booklet.



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ACOUSTICAL MANUFACTURING CO LTD

HUNTINGDON, HUNTS · Telephone: HUNTINGDON 361.

The NEW I. C. S. LEARN-AS-YOU-BUILD PRACTICAL RADIO COURSE

LEARN RADIO as you build your own receiver and testing instruments

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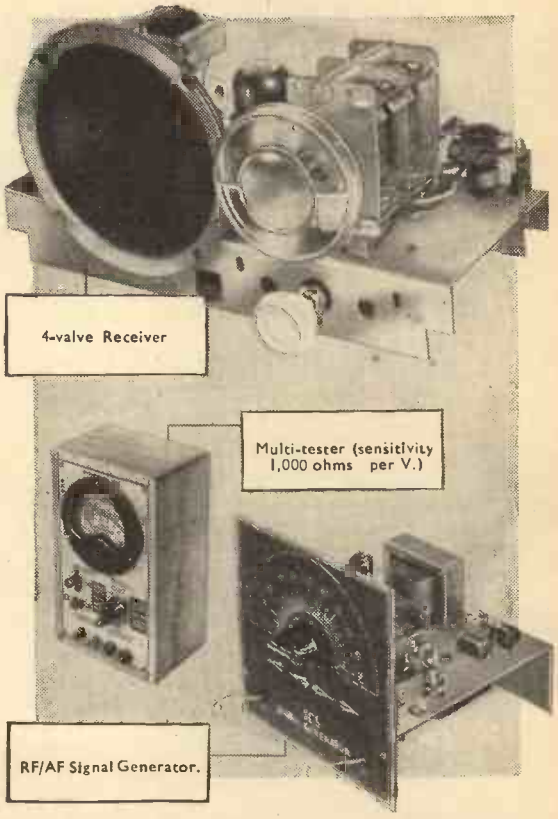
TRAINING TO SUIT YOUR NEEDS Whether you plan to have a business of your own, to become a service engineer, to pursue a career in the radio industry, or to take up radio as a serious hobby—this course provides the ideal way of obtaining a firm foundation of essential knowledge. If you are an intending examination candidate, I.C.S. training offers you the most thorough preparation you could have.



All the equipment shown here is sent to the student as part of the course and the cost is included in the fee.

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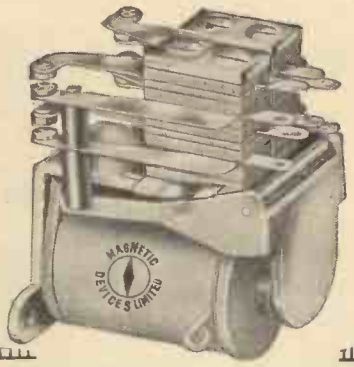
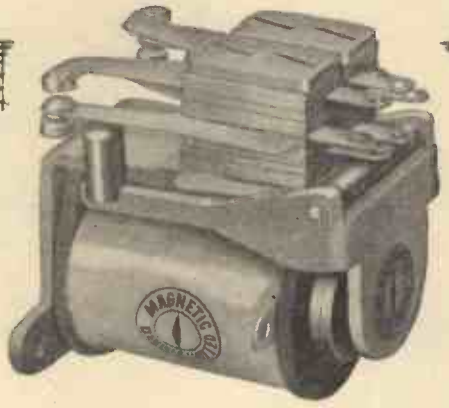


Magnetic Devices LTD.



Upper Illustration; Series 596. D.C. operated, Max. V. 140. Contact rating up to 5A. continuous. Switching: One to six poles in various combinations. Overall size: 1 7/16″ long by 1 3/32″ wide by 1 25/32″ deep. Coil consumption 0.5 to 3 watts.

Lower Illustration; Series 590. A.C. operated, Max. V. 250. Contact rating up to 5A. continuous. Switching: One to four poles in various combinations. Overall size: 1 7/16″ long by 1 3/32″ wide by 1 25/32″ deep. Coil consumption 2 or 4VA.

Coils are wound for standard voltages up to 250V.A.C. and 140V.D.C. Coils can be supplied vacuum impregnated if required.

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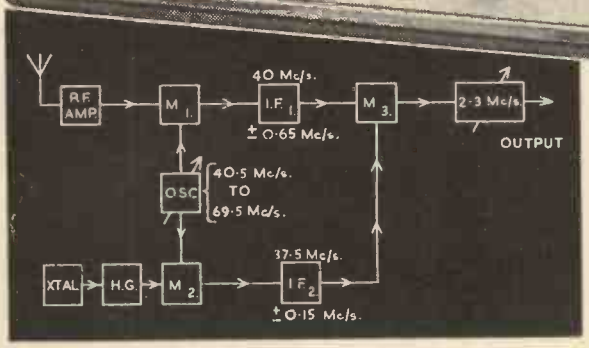
"This is more than a receiver . . . . . it's a revolution!" SAY OPERATORS

If you use H.F. communication equipment, the R.A.17 will interest you



Write for full specification and performance data today

CONSIDER THESE SENSATIONAL FEATURES:

- ★ 0.5 to 30 Mc/s in 30 bands
- ★ Band changing without switches or turrets
- ★ 60in. film scale giving 200 c/s setting accuracy
- ★ Overall stability after warm-up within 100 c/s
- ★ Extreme sensitivity: 3μV. for 20 db S/N ratio (30% modulation)
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- ★ Modular construction allows easy servicing
- ★ Alternative British or American valves and connectors
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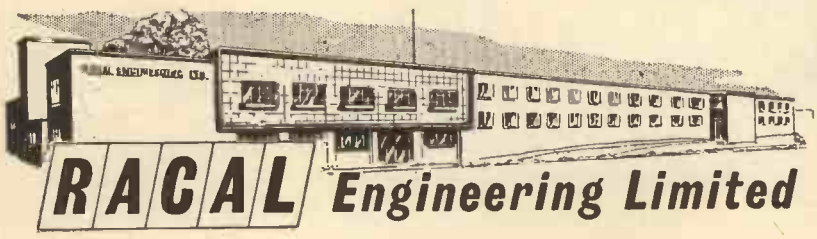

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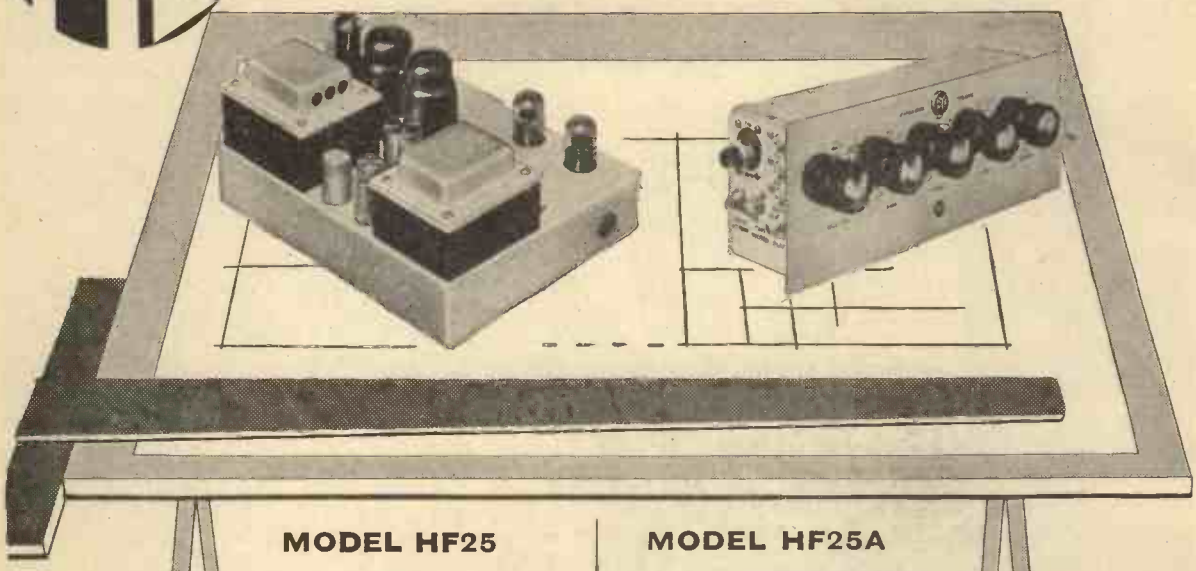


MODEL HF25

The amplifier has been critically designed to give living expression to recent improvements in recording and broadcasting techniques. Clear life-like reproductionis ensured by the low harmonic distortion and by the infinite damping factor. 25 watts undistorted output is ample for any home system.

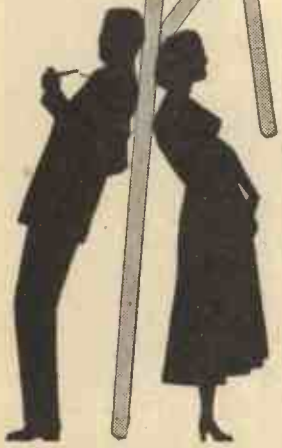
MODEL HF25A

The pre-amplifier has phono-jack inputs for radio, microphone, pick-up, tape recording and 4 equalisation positions for U.S. LP, EUR. LP (R.I.A.A.,) U.S. 78 and EUR. 78. Amplifier can be controlled from distances of 20 ft. without loss of performance. In walnut and sycamore veneered cabinet or chassis form.

The highest standard of performance and reliability is ensured by neat chassis layout and superlative workmanship.

Very wide frequency range, 2—160,000 c.p.s. 26 db of negative feedback over the entire audible range.

A range of plug-in pick-up compensators allows quick and easy matching of any type of pick-up.



PACKAGED HI-FI

These small matching Pye plug-in units are bringing high fidelity to the ordinary listener *at a price he can afford*. They're simple to operate, install in minutes and blend at once with modern furnishings.

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MINIATURE SOLDERING INSTRUMENTS

NOW SERVING WITH THE BRITISH TRANS-ANTARCTIC EXPEDITION

OFFICIAL REPORT

"Models 9, 12 and 24 were tested in a cold chamber at −40°C with a voltage supply of 12.6 volts. Using Models 9 and 12, no difficulty whatsoever was encountered in soldering wire and small components to a tag board. It was even possible to tin areas on a large sheet of thin tin plate. Model 24 melted aluminium solder with ease. The only modification which had to be made for service in the cold was the replacement of the plastic insulated leads by rubber wire."

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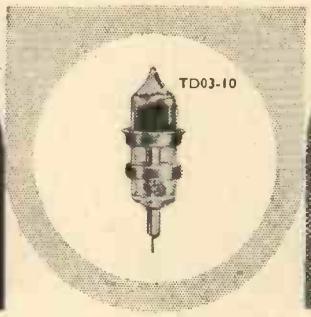
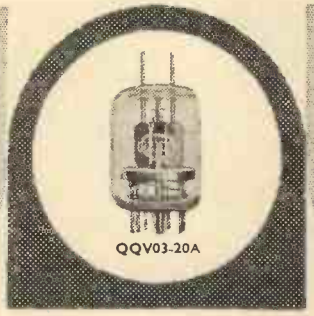
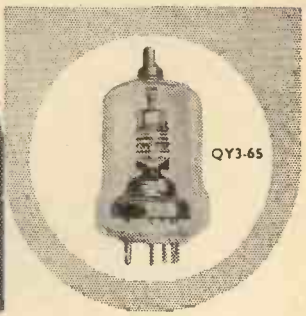
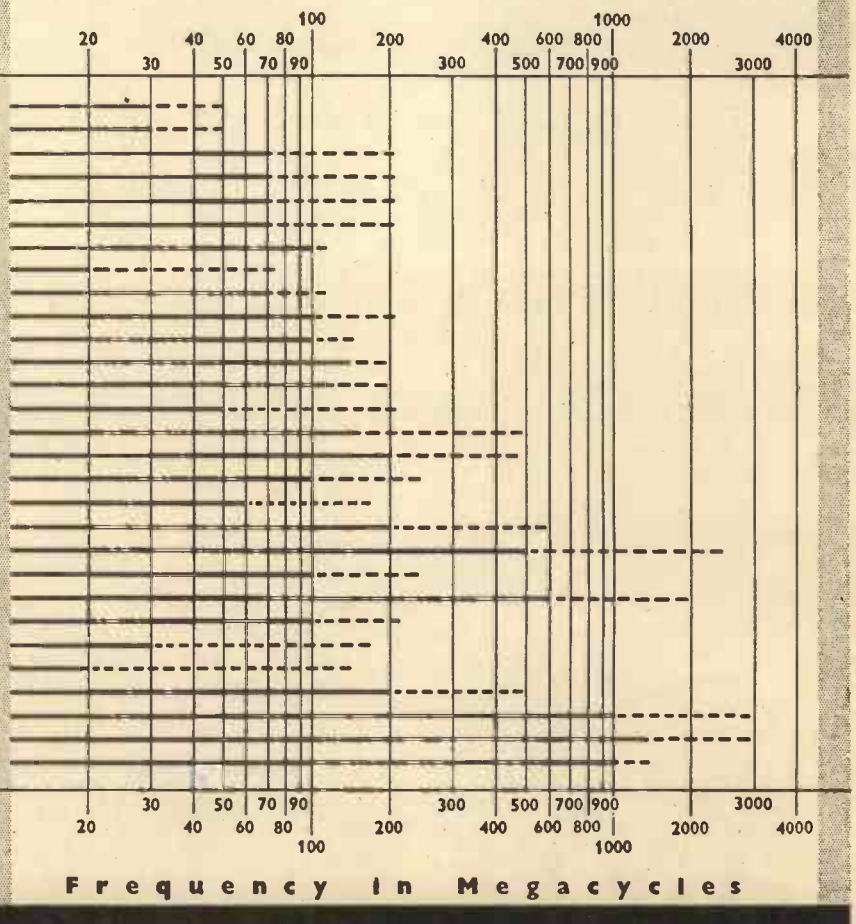
a transmitting all communications







Valve Output Power in Watts	Type Number
10,000·0	TY7-6000A
10,000·0	TY7-6000W
6,900·0	TY6-5000A
6,900·0	TY6-5000W
4,100·0	QY5-3000A
4,100·0	QY5-3000W
1,690·0	TY4-500
1,440·0	TY4-350
1,000·0	QY4-250
900·0	QY4-500A
845·0	TY3-250
390·0	TY2-125
375·0	QY3-125
280·0	QY3-65
195·0	QV1-150A
90·0	QQV06-40A
87·0	QQV07-40
52·0	QV06-20
48·0	QQV03-20A
27·0	TD1-100A
26·0	QQV04-15
23·0	TD04-20
16·0	QQV03-10
10·0	QV03-12
7·9	QV04-7
6·0	QQV02-6
2·8	TD03-10
2·0	TD03-10F
0·02	TD05-12



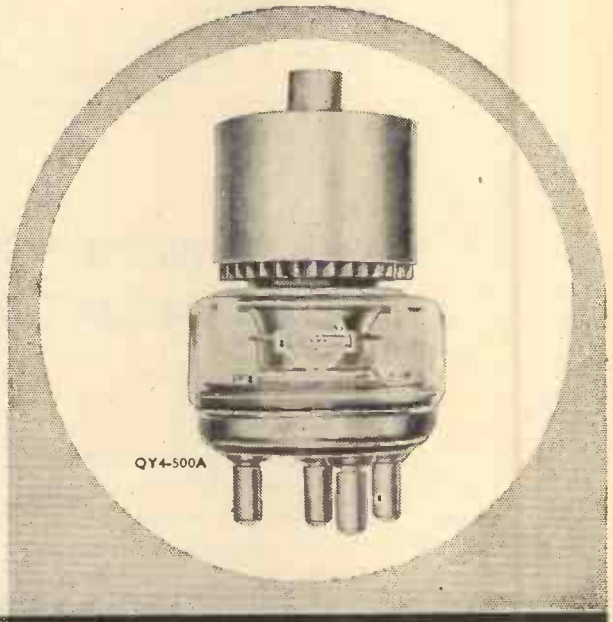
valve range for equipment

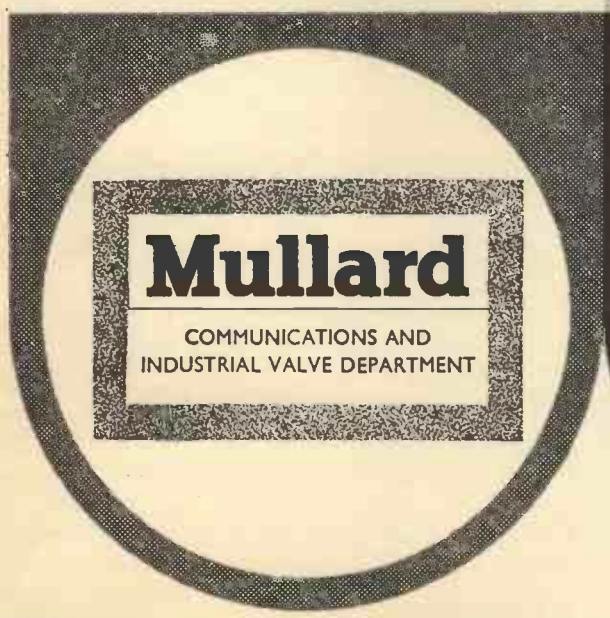
This extensive range of work-proven transmitting valves fills the wide and diverse needs of communications equipment manufacturers. The performance of this valve group extends to frequencies as high as 3,000 Mc/s for 0.5W and to powers up to 6.9kW at lower frequencies.

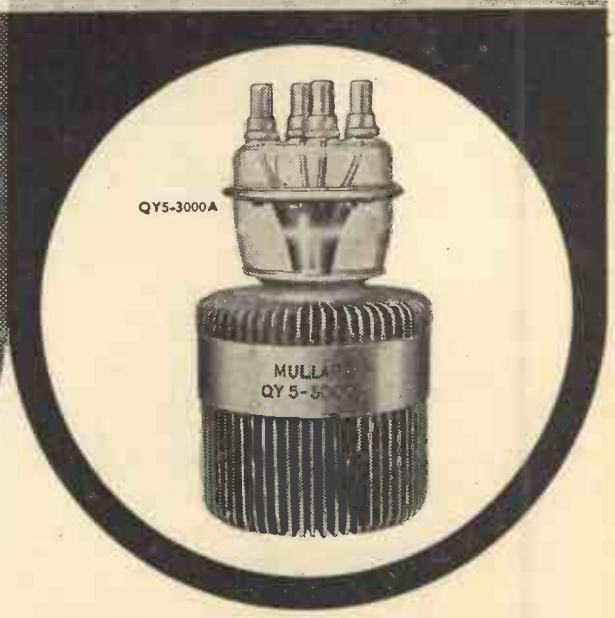
The Mullard technical advisory service is always at the disposal of manufacturers to answer questions relating to the applications and suitabilities of these valves.

Transmitting Valve Data

The chart on the left has been compiled to acquaint designers with the range and scope of Mullard transmitting valves available for communication purposes, and to facilitate the selection of suitable types for given applications. The power quoted is the maximum valve output available with Class C telegraphy operation up to the frequency indicated by the junction of the solid and broken lines. The extent to which a valve may be used at higher frequencies with reduced ratings is given by the broken line.
More detailed information may be obtained from a leaflet on this range of valves and from individual data sheets—all of which are available on request at the address below.







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MV305a

Another New Wayne Kerr Bridge

THE WAYNE KERR COMPONENT BRIDGE FOR LABORATORY OR WORKSHOP B.521

THE moderately priced B.521 is the second of a range of new instruments of very advanced design resulting from concentrated development of the transformer ratio-arm technique.

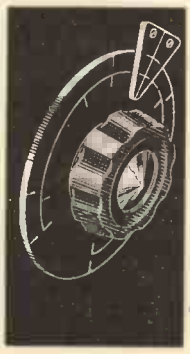
Operating at mains frequency, the B.521 has an effective ratio of 10^{12}:1 and is intended for the rapid and direct measurement of virtually all components and networks likely to be encountered in electronic apparatus, whether in the laboratory or the service workshop.

The usual three-terminal facility associated with bridges of this design permits the measurement of complex impedances in situ, that is to say, an impedance between two terminals can be determined regardless of the presence of other impedances between either or both terminals and a third point. A simple rearrangement of the test leads covers four-terminal measurements when required.

The low impedance ranges together with the in situ facility make it possible to measure switch contact resistance, dry joints, earth bonding efficiency, high value electrolytics, etc.

SPECIFICATION

Capacitance : 1 pF to 5F · Inductance : 1 μH to 0.5 MH. Resistance : 1 m Ω to 1000 M Ω · Accuracy : 2% · Power Supply : 110/125 and 200/250v · Dimensions : 17" x 7" x 11½" high · Weight : 25 lbs. approx. · Price : £75.0.0



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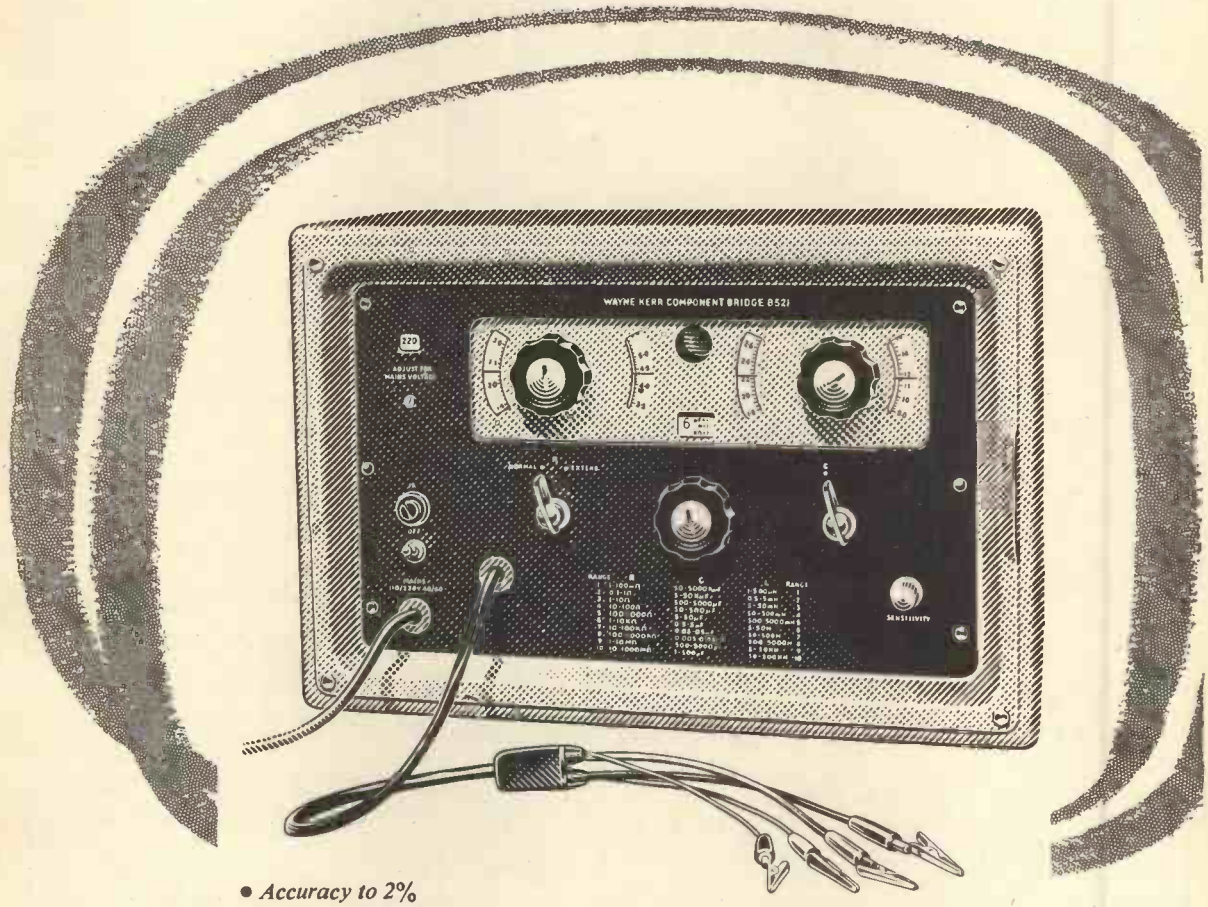

- *Accuracy to 2%*
- *Two continuously variable controls indicate independantly the resistive and reactive terms.*
- *Two, three or four-terminal measurements over an extremely wide range.*
- *The Bridge can be used to measure—in situ if required—the following:*

DRY JOINTS HIGH CAPACITANCE ELECTROLYTICS WITH OR WITHOUT D.C.
INSULATION RESISTANCE SWITCH CONTACT RESISTANCE
EFFECTIVENESS OF TRANSFORMER SCREENS INDUCTORS CARRYING D.C.
CABLE CONNECTORS EARTH BONDING EFFICIENCY

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(Made in Holland)

The special dual-cone construction of Philips high fidelity loudspeakers ensures a smooth response over the entire audible range, with efficiency and transient response of a high order. The spatial distribution of acoustic energy is excellent — even at the highest frequencies.

Both cones are driven by the same coil and magnet, resulting in similar sensitivities for high and low frequencies. The air gap has been made long and the coil moves in a homogeneous magnetic field at all times; a copper ring is incorporated in the air gap to keep the voice coil impedance constant over the whole frequency range.

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N.B. These speakers may be used on their own or with another suitable speaker, using a crossover network.

*Your high fidelity dealer can obtain these loudspeakers for you.

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AWA

Teleradio* 5A

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Made by AWA, Australia's largest manufacturer of telecommunications equipment of all types. AWA are approved contractors to the Crown Agents.
The 5A is in use by Governments and private networks in many places. Please write for details.

SPEECH COMMUNICATION

The AWA Teleradio 5A is a low-power H.F. transmitter-receiver for distances up to several hundred miles over land or sea.
One to four channels between 2 and 9 mc/s may be pre-tuned in the crystal-controlled transmitter. The receiver also tunes from 550 to 1540 kc/s.
The standard model operates from 12-volt battery. An A.C. model is also available.

* *Regd. Trade Mark 34699 (Aust.)*

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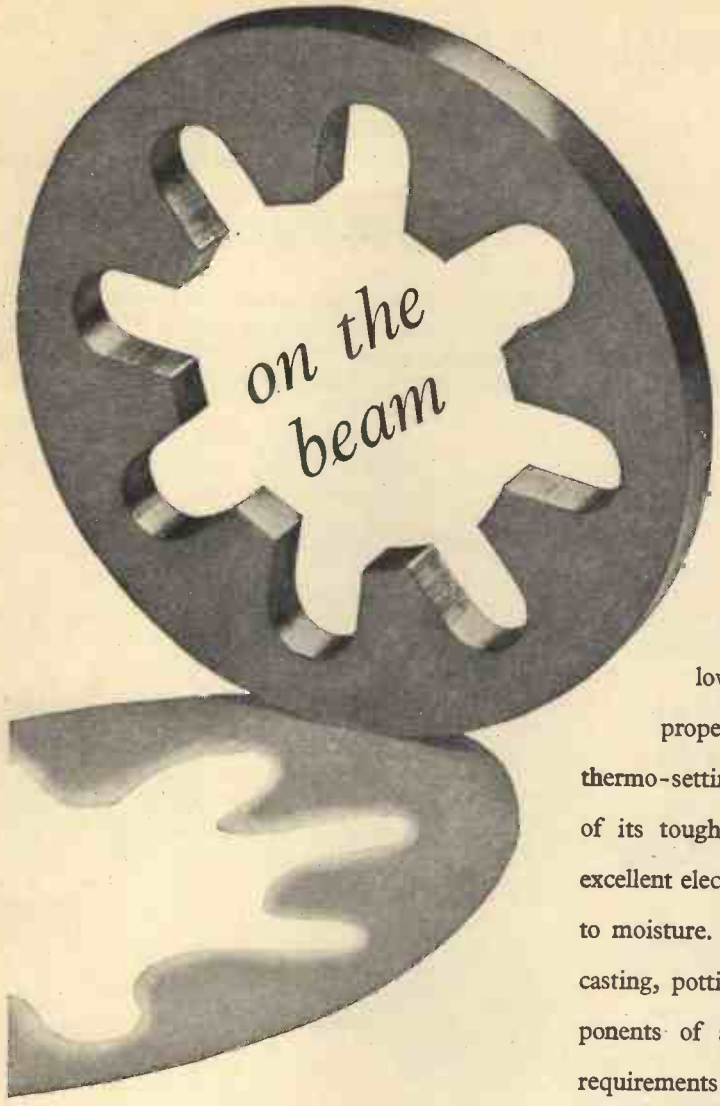

Cores for Cathode ray beam deflection made by Salford Electrical Instruments Ltd. are formed by powder metallurgy incorporating 'Araldite' as a constituent. Construction of these cores calls for durability, low dielectric losses and good machining properties, whilst the resin used must be thermo-setting. 'Araldite' was chosen because of its toughness, remarkable adhesion to metals, excellent electrical properties, stability and resistance to moisture. This outstanding material is the ideal casting, potting or sealing resin for electrical components of any size, and complies with service requirements relating to sealing of components.

'Araldite' epoxy resins have a remarkable range of characteristics and uses:

They are used
- ★ **for bonding metals, porcelain, glass, etc.**
- ★ **for casting high grade solid insulation.**
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- ★ **for producing glass fibre laminates.**
- ★ **for producing patterns, models, jigs and tools.**
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'Araldite' *epoxy resins*

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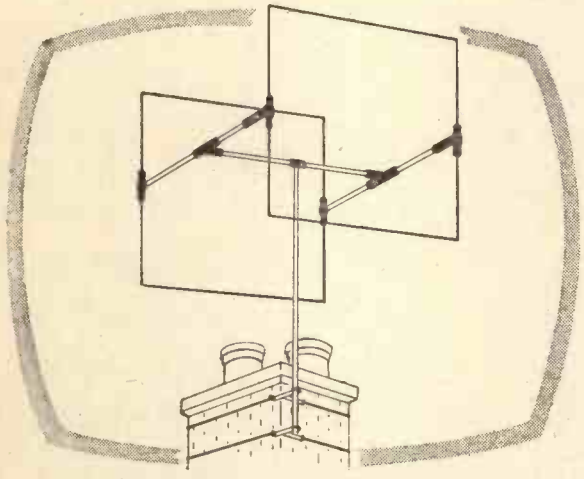
A SUPER-FRINGE T/V AERIAL *for Band I*



the LABGEAR BI-SQUARE *outdoor*

The most remarkable advance in aerial design. Only half the size of ordinary Band 1 arrays, the BI-SQUARE is light in weight, easy to erect and gives 11-12dB gain. Factory pre-assembled and supplied complete with 12 ft. mast and double chimney lashings.

Model 110 (head only) £6.10.0 **Model 110/X3 (Complete) £10.17.6**

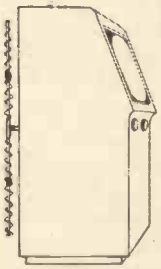
LOFT MOUNTING VERSION

The first long range loft mounting aerial, this version of the BI-SQUARE eliminates installation problems and under average conditions provides first class Band 1 reception up to 40/50 miles.

Model 110/L £6 · 10 · 0

First of its kind

The Spiral



Another new Labgear development! Designed to meet the demand for a neat, unobtrusive aerial for Bands I and III, the Spiral has a range of approximately 10 miles and is supplied ready to plug into the set.

Send now for Labgear Wall Chart giving complete details of all aerials for B.B.C., I.T.A. and V.H.F./F.M.

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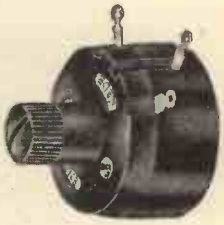
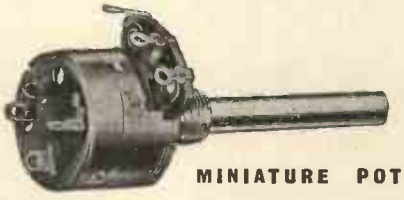
with concentric operating spindles. Incorporating many outstanding design features, including multiple contact rotors and thorough screening between sections. Control spindles can be supplied to suit customers' requirements. Type 136 less switch. Type 137 with SPST switch. Type 138 with DPST switch.

PRE-SET POTENTIOMETERS



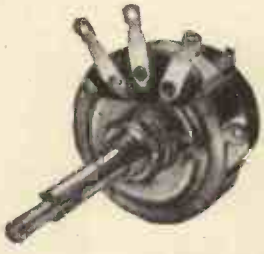
Completely enclosed in high-grade phenolic mouldings. Solder tags heavily silver-plated for quick soldering. Fully insulated spindles with integral control knobs. Tapped for 2-hole 6 B.A. fixing on ¾" centres. Type 126, wire-wound. Type 127, carbon.



MINIATURE POTENTIOMETERS

⅛" diameter: utmost reliability within a very small compass. Positively located soldering tags, silver-plated for easy soldering. All steel parts rustproof. Standard values available, from 5000 ohms to 2 megohms. Type 115 less switch, Type 105 with specially designed 2-pole Q.M.B. switch.

CONCENTRIC SWITCH POTENTIOMETERS



Thorough screening between switch and potentiometer. Concentric operating spindles give independent operation of switch or potentiometer with 'one-control' simplicity. Quick make-and-break action mains switch. Knob location to suit specified requirements. Type 154 with SPST switch, Type 155 with DPST switch.

The wide range of EGEN controls includes also: Standard Carbon Potentiometers Type 102, Pre-set Resistors, Inductance Coil Assemblies, Sub-Miniature Potentiometers, (for use in miniature electronic apparatus) and TV Aerial Plug and Socket.

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Model 5in. G Price **25/8** inc. P.T.

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ELMAG High Fidelity Units

Designed to give good quality at domestic volumes. For a power output stage providing more than 4 watts, 2 or more speakers are recommended.

Flux Density 8,000 gauss (27,500 Maxwells). Frequency Response 40-12,000 c.p.s.

9 x 5in. Model 59T. Price 38/2 inc. P.T.

All prices are for speakers without transformers.

TRADE TERMS: 33⅓%

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SWITCHES & SIGNAL LAMPS

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3-amp., 250v.

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Neon Signal Lamp
½" hole fixing

T622, Toggle Switch
D.P.C.O. 3-amp., 250v.

S.L.90/SB
Low Voltage
Signal Lamp
for M.E.S. bulbs

K.75: Small Pointer Knob

Write for Catalogue No. 129

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Prompt delivery at competitive prices.

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for general insulation

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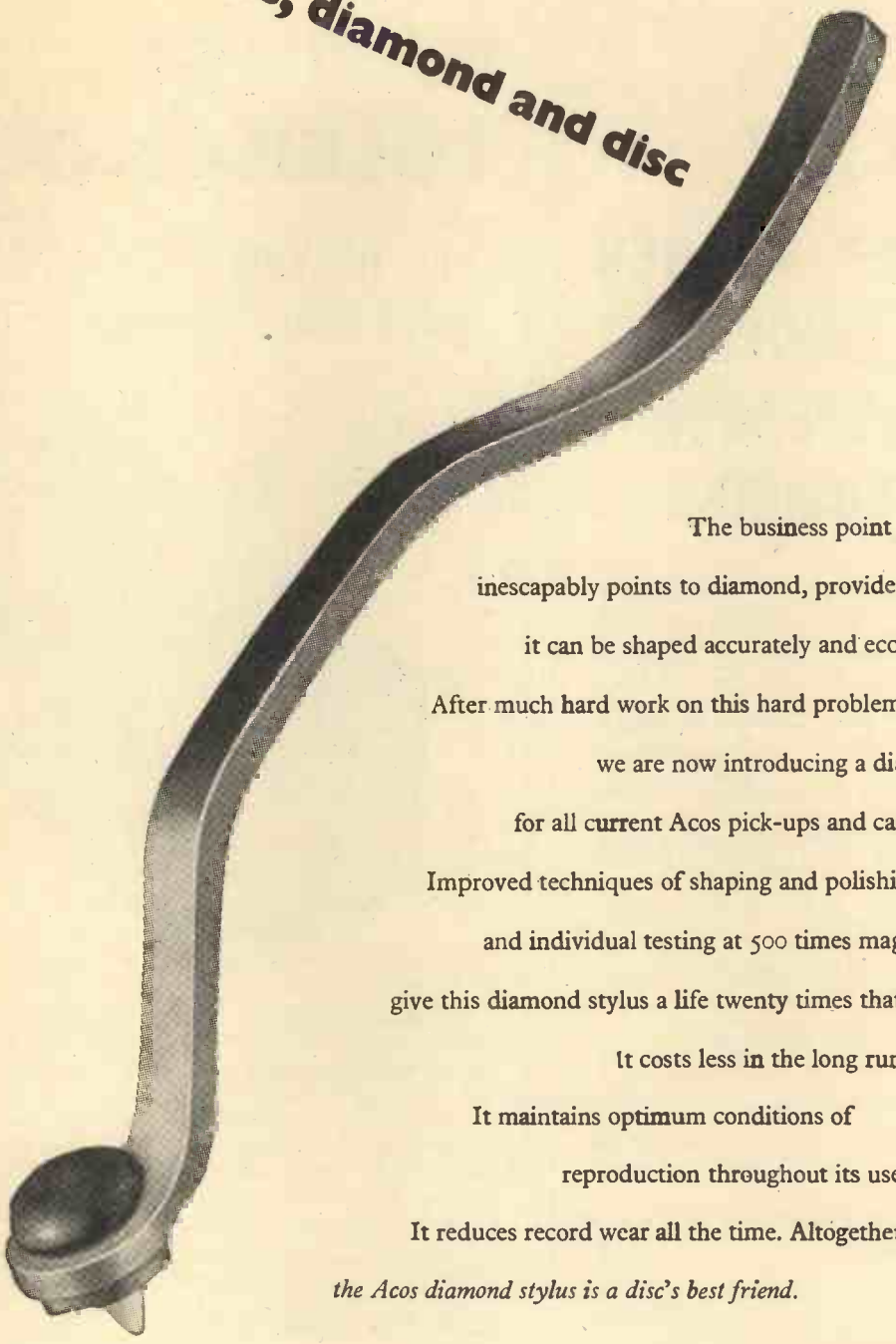

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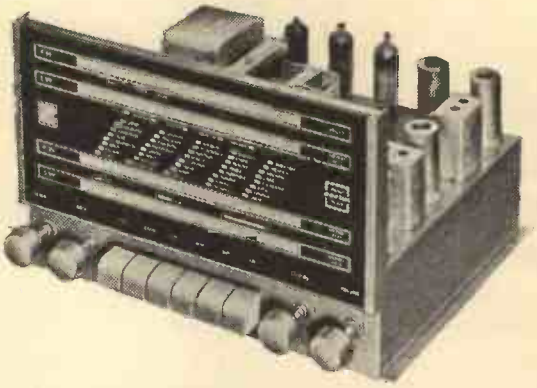

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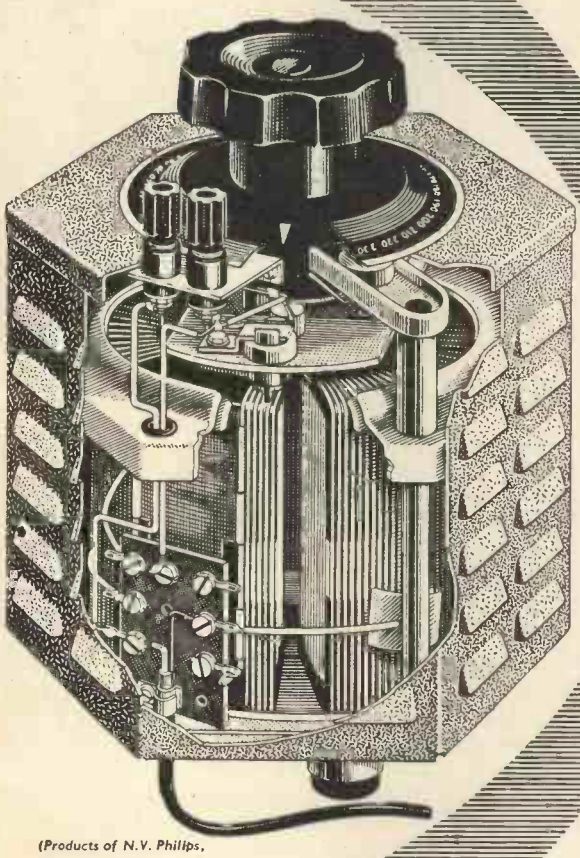

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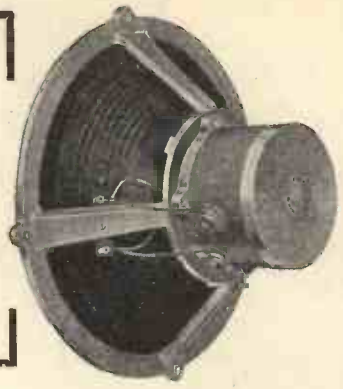

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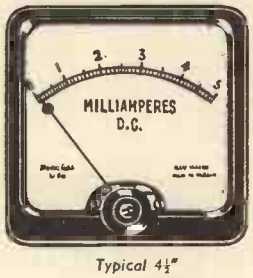

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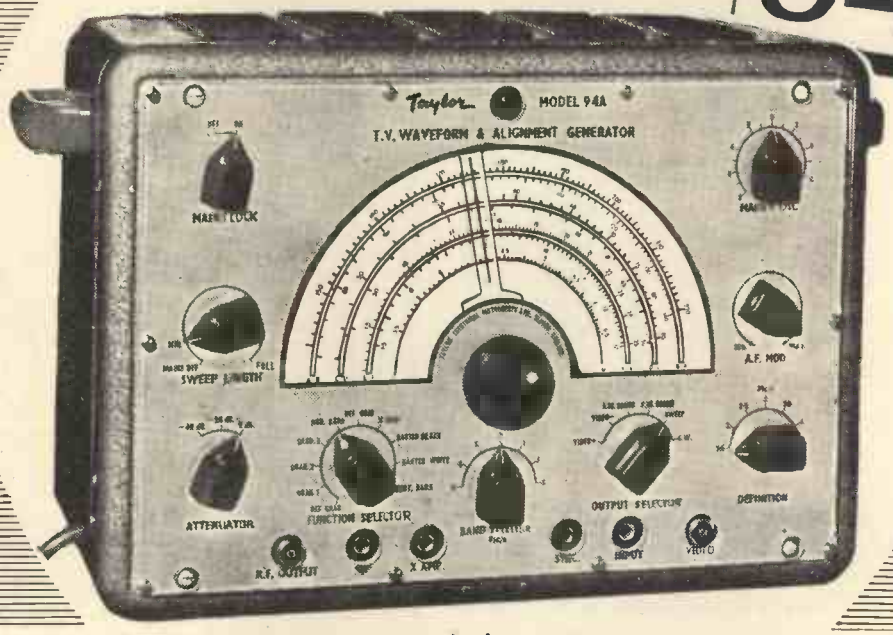

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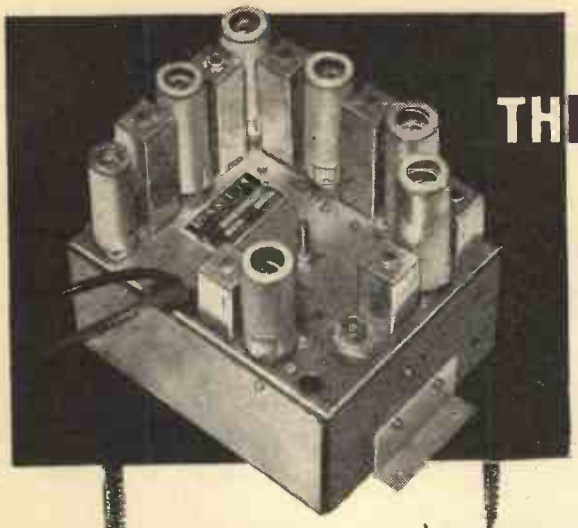

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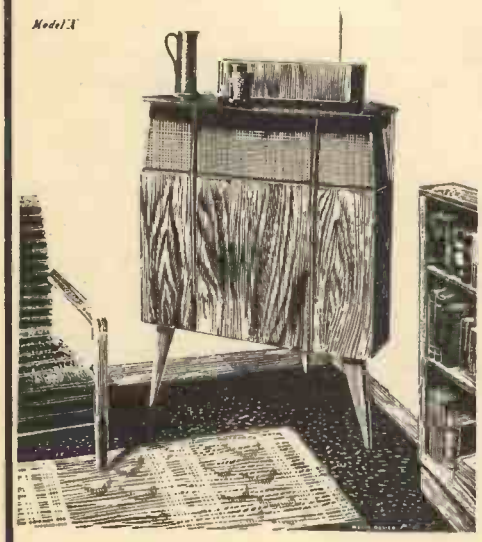

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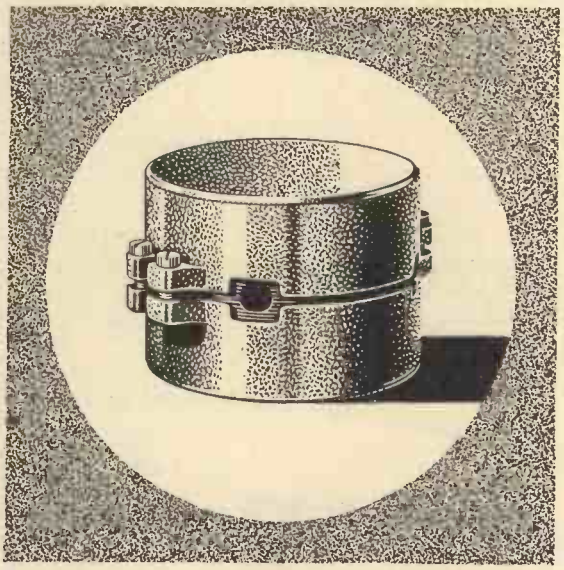

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E.A.R. Mullard 610	19 19 0	48/10	9 19 6	18/4	19 19 0
Rogers Senior	42 0 0	102/8	21 0 0	38/2	42 0 0
Rogers Junior	26 0 0	63/7	13 0 0	24/2	26 0 0
Rogers Minor Mark III	14 0 0	35/7	7 0 0	14/2	14 0 0
E.A.R. 750	9 9 0	24/4	4 14 6	10/5	9 9 0
B.C.A. Hi-Fi Amplifier and Pre-Amp.	48 0 0	117/4	24 0 0	44/6	48 0 0
Grampian 5-10-B	27 0 0	66/–	13 10 0	25/1	27 0 0
F.M. Tuners					
Quad Tuner F.M.	30 9 0	74/6	15 4 6	28/3	21 0 0
Leak F.M.	35 10 0	86/10	17 15 0	32/11	25 0 0
Rogers F.M.	24 17 0	60/9	12 8 6	23/3	17 10 0
Jason Switched F.M.	16 12 7	41/5	8 6 4	16/5	11 19 3
Ferguson F.M. Tuner	16 16 0	41/10	8 8 0	16/6	12 2 7
Chapman F.M. 85	25 4 0	61/8	12 12 0	23/6	18 0 0
Chapman F.M. 81	22 1 0	53/11	11 0 6	20/5	15 15 0
Speakers					
Wharfedale W.15 CS	17 10 0	43/4	8 15 0	16/6	17 10 0
Wharfedale Super 12 CSAL	17 10 0	43/4	8 15 0	16/6	17 10 0
Wharfedale W.12 CS	10 5 0	27/3	5 2 6	11/1	10 5 0
Wharfedale Golden 10	8 0 11	21/3	4 0 6	9/2	5 15 0
Wharfedale Super 8 CSAL	7 6 11	19/8	3 13 6	8/7	5 5 0
Wharfedale SFB/3 Complete Speaker Unit	39 10 0	96/6	19 15 0	36/8	39 10 0
G.E.C. Metal Cone	9 5 0	23/11	4 12 6	10/2	6 13 7
Goodmans 150 Mark II	10 15 9	28/5	5 8 0	11/6	10 15 9
Audiom 60 (12in.)	9 2 9	23/8	4 11 0	10/1	9 2 9
Axiom 22	15 9 0	38/9	7 14 6	15/4	15 9 0
Transcription Units					
Garrard 301	26 8 2	64/7	13 4 1	24/6	19 0 0
Connoisseur (T)	28 11 4	69/9	14 5 8	26/6	20 0 0
Collaro 4T200 with PU	19 10 0	47/10	9 15 0	18/11	14 1 6
Collaro 4T200 without PU	14 18 0	37/7	7 9 0	14/11	10 15 0
Lenco GL 55	17 10 4	43/5	8 15 2	17/1	12 12 0
Lenco GL 56	23 7 0	56/6	11 13 6	22/–	16 16 0
Lenco GL 50/4	21 17 10	53/7	10 18 11	20/9	15 15 0
Woollett	21 0 0	51/4	10 10 0	20/–	15 10 0
Pickups					
Goldring L.56/500	6 19 0	18/10	3 9 6	8/4	5 0 0
Goldring L.56/500/SD	11 16 4	30/8	5 18 10	12/5	8 10 0
Complete Collaro O. or P. Head	5 0 5	14/5	2 10 3	6/8	3 12 6
Complete Garrard TP1210	5 4 3	14/9	2 12 2	6/10	3 15 0
Leak standard with diamond LP and Std. Head	20 4 9	49/5	10 2 5	19/5	14 5 0
B.J. with Shell and C.12 Head	6 12 7	18/1	3 6 4	8/1	4 14 8
Connoisseur	28 11 0	69/9	14 5 6	26/6	20 0 0

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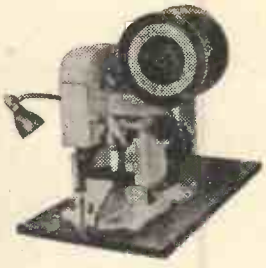

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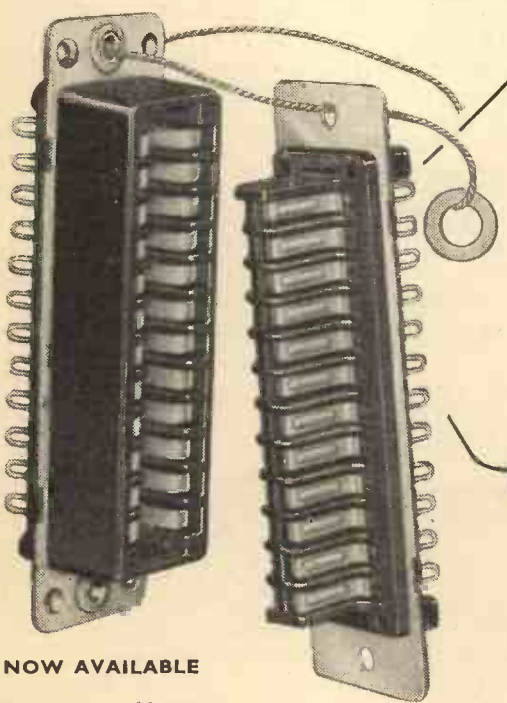

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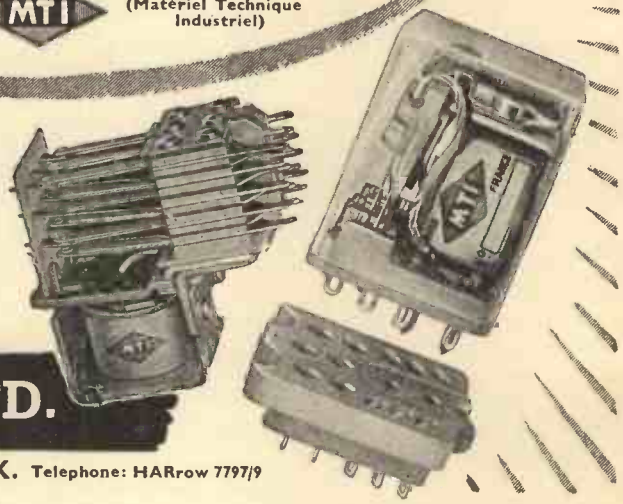

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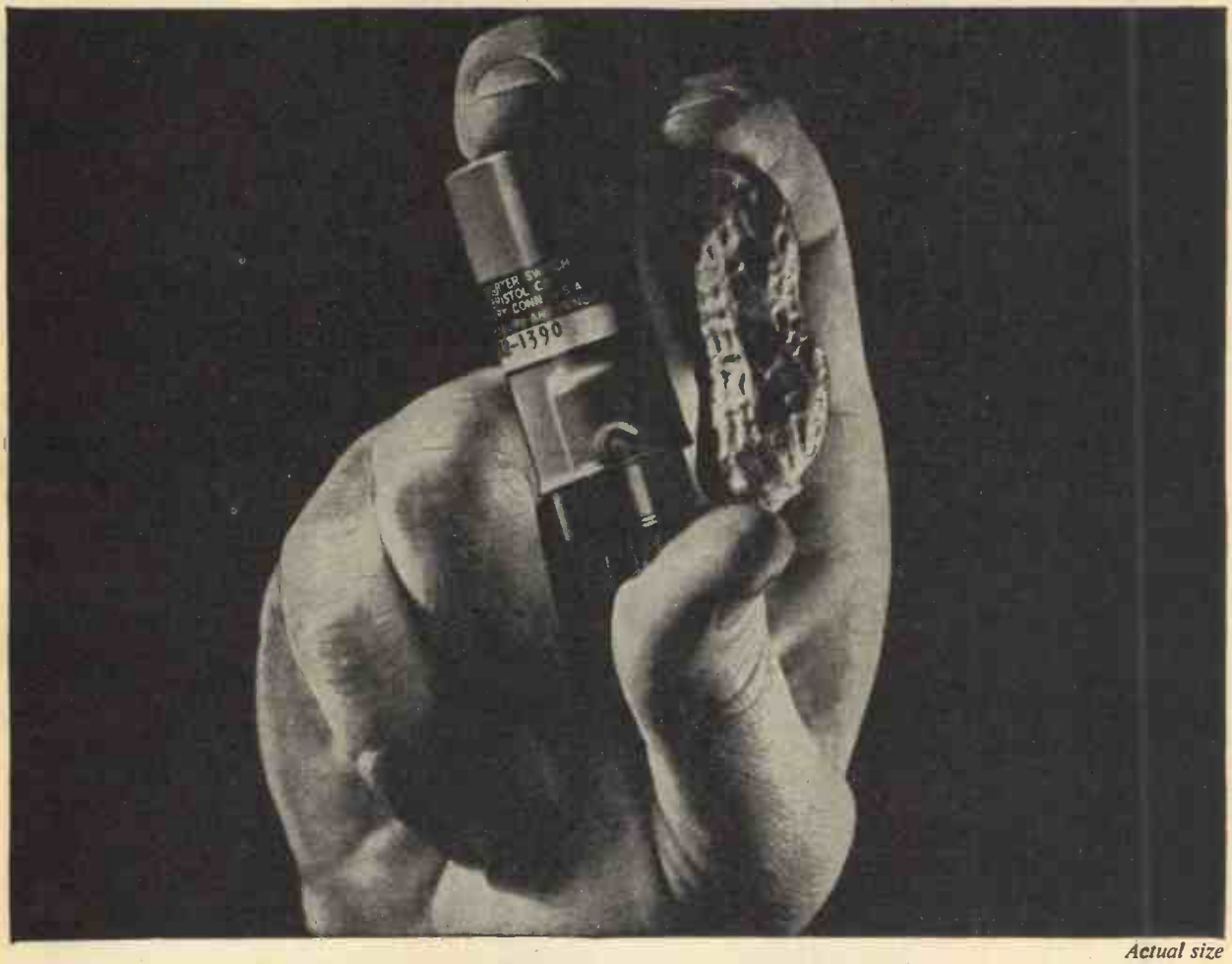

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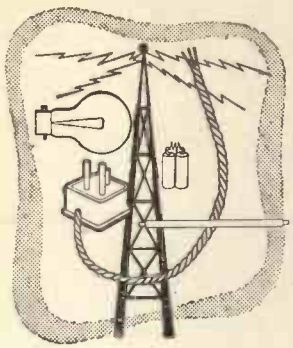

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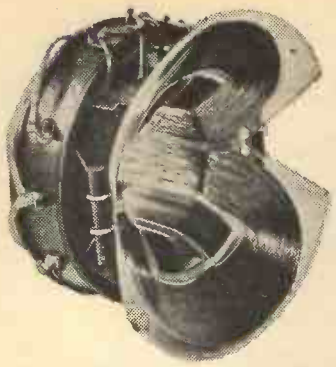

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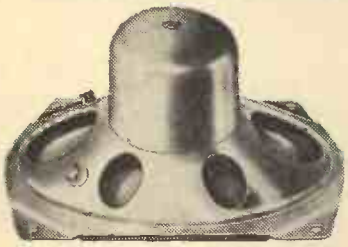

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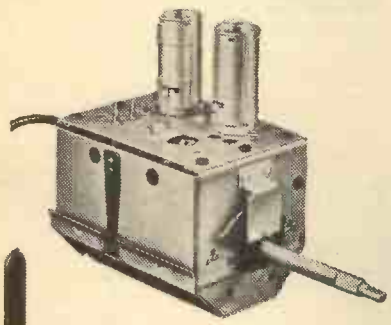

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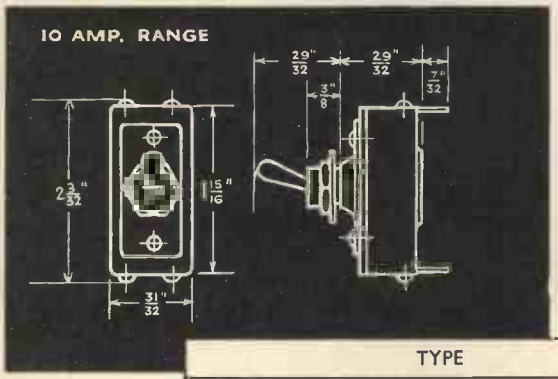

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The Painton 10 Amp. Toggle Switches are fully Type-approved to the appropriate R.C.S.C. Specification.

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AVERAGE INTERNAL RESISTANCE:
Less than ·002 ohm.

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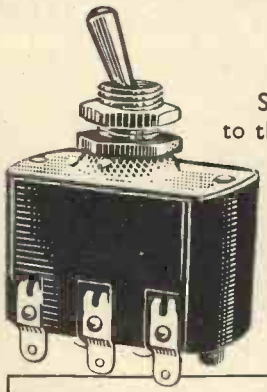
As 500705, but fitted for two-hole mounting by 4 B.A. bushes on 1 3/16" fixing centres.	501089
DOUBLE POLE ON/OFF. Dimensions and finish of bush and lever to conform to current RCL 151.	501402



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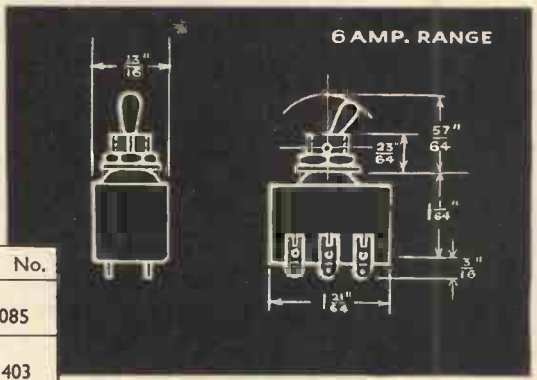

TYPE	CAT. No.
DOUBLE POLE CHANGE OVER. Dimensions shown in line drawing. Heavy duty chrome finish.	501085
DOUBLE POLE CHANGE OVER. Dimensions and finish of Bush and Lever to conform to current RCL 151.	501403
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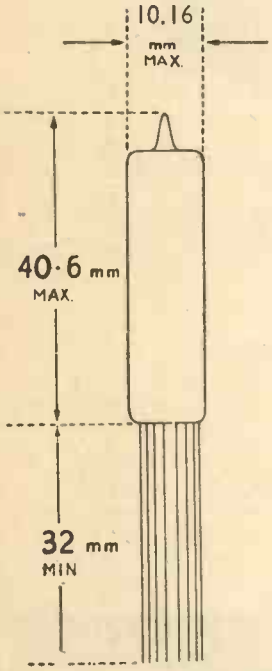

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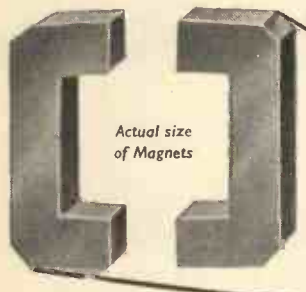

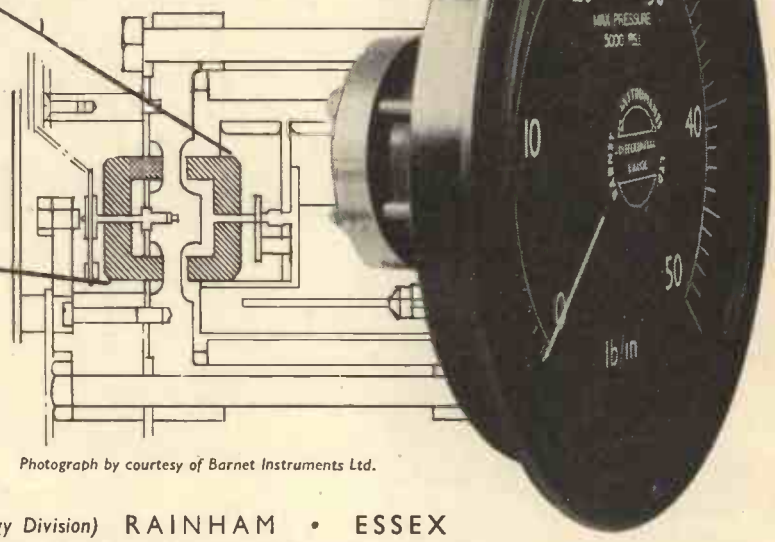

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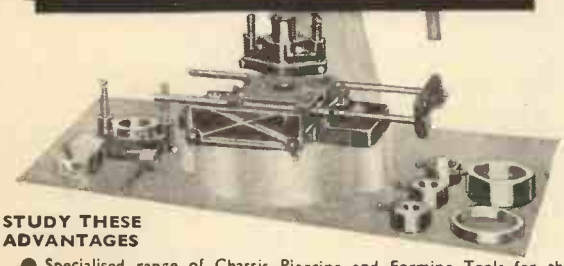

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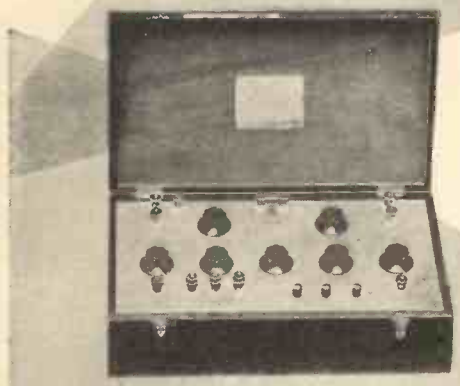

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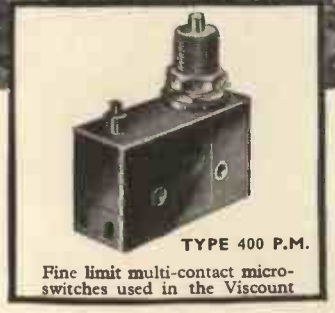


TYPE 400 P.M.
Fine limit multi-contact micro-switches used in the Viscount

PYE LIMITED, SWITCH DIVISION
OTEHALL WORKS, BURGESS HILL, SUSSEX. TEL: BURGESS HILL 2791/2

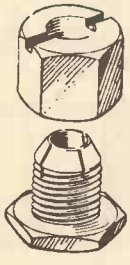
PRE-SET CONTROL LOCK

Designed to lock the spindles of pre-set potentiometers or trimmers without rotational or lateral displacement of shaft.

Will accept wide range of panel thicknesses.

TYPE P

Very attractive appearance for panel mounting.



TYPE C

Send for leaflet A.1

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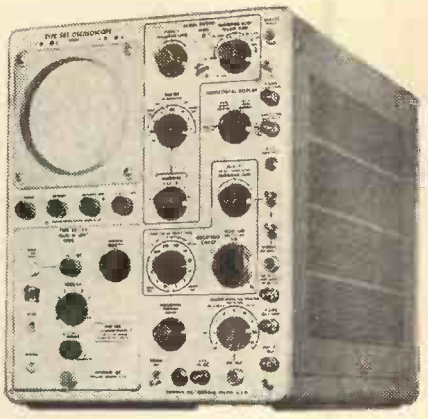
Why are there *TWO SWEEP GENERATORS* in these TEKTRONIX® oscilloscopes ?



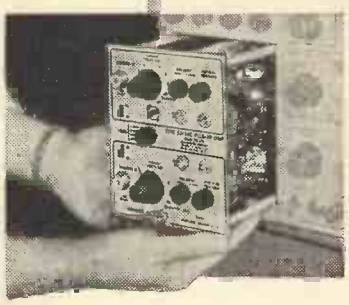
The extra sweep generator makes an oscilloscope much more useful. With the Tektronix delaying sweep you can . . .

1 START THE OSCILLOSCOPE SWEEP WITH THE FIRST TRIGGER RECEIVED AFTER A CONTROLLABLE TIME-DELAY PERIOD. This is an important reason for the extra sweep generator and its associated pickoff circuit in Tektronix Type 535 and Type 545 Oscilloscopes. Triggering the delayed sweep by the observed signal guarantees a jitter-free display . . . ideal for examination of time-modulated pulses and signals with inherent jitter.

2 START THE OSCILLOSCOPE SWEEP AT THE END OF A CONTROLLABLE TIME-DELAY PERIOD . . . convenient for observation of occurrences after an accurately determined time interval.

3 MAKE MORE ACCURATE TIME-INTERVAL MEASUREMENTS. A calibrated ten-turn time-delay control divides each of the twelve delay ranges into a thousand units. Range accuracy is within 1%, incremental accuracy on any range is within 0.2% of full scale.

4 TRANSFER PART OF A DISPLAY TO A FASTER SWEEP. By initially displaying a signal on the extra, delaying sweep, and then transferring it to the main oscilloscope sweep, a continuously adjustable horizontal expansion can be obtained. Degree of magnification is determined by the time/cm ratio between the two sweeps. The average jitter of 1 part in 25,000 permits practical use of very large magnifications. Further, the exact portion of the display on the delaying sweep that will appear on the faster main sweep is positively identified by trace brightening. Unblanking pulses for both sweeps are applied to the crt grid, causing the main sweep to show up as a brightened portion of the display on the delaying sweep.



5 ARM THE OSCILLOSCOPE SWEEP FOR TRIGGERED ONE-SHOT OPERATION. A front-panel pushbutton or an electrical signal from a remote location can be used instead of the internal delayed trigger to arm the sweep. After the button is pressed, or the pulse received, the next trigger causes the main sweep to fire once and revert to the locked-out condition. Photographic recordings of a single transient made in this manner cannot be blurred by spurious signals following its occurrence. Because the single sweep can be triggered any time after the button is pressed or the pulse received, the time of occurrence need not be accurately predictable.

GREATER VERSATILITY PREFERRED

Customer preference for the Tektronix Oscilloscopes with a delaying sweep, Type 535 and Type 545, indicates that the increased utility is valued at much more than the small additional cost. Application possibilities of these versatile instruments make them worthy of your serious consideration.

TYPE 535 and TYPE 545 CHARACTERISTICS

Delay Specifications

A calibrated twelve-step range control and a ten-turn precision control provide for continuously-variable coverage of the full sweep-delay range—1 μsec to 0.1 sec. Range accuracy is within 1%, incremental accuracy within 0.2% of full scale. Time jitter is less than 1 part in 20,000 in conventional sweep-delay operation. Display is completely jitter-free in triggered operation. The delaying sweep can be used as a rate generator, producing trigger rates from 10 cycles to 40 kc, continuously adjustable. The delayed trigger is available at a front-panel connector for external applications.

Other Specifications

Main-sweep range is 0.02 μsec/cm to 12 sec/cm continuously variable, with 24 calibrated steps accurate within 3%. Accelerating potential is 10 kv. Vertical-amplifier response with Type 53/54K Fast-Rise Plug-in Unit. . . . Type 535, dc to 11 mc—Type 545, dc to 30 mc. Seven plug-in vertical preamplifiers are available for complete signal-handling versatility.

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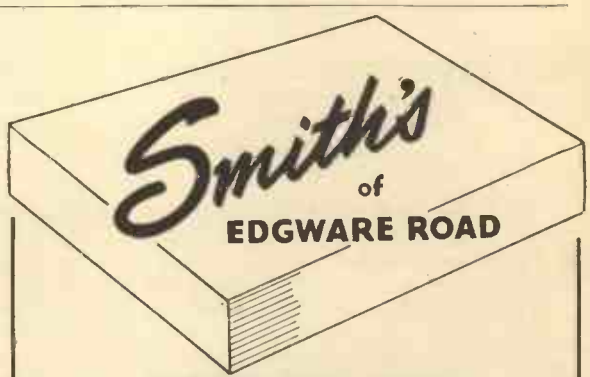
and Zentralverband der Elektrotechnischen Industrie, Frankfurt/M., Am Hauptbahnhof 12



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Made in our own works from commercial quality half-hard aluminium of 16 s.w.g. thickness, these chassis will carry components of considerable weight and normally require no corner strengthening.

Standard stock sizes (in inches) are as follows:—

6 x 4 x 2	5/-	12 x 5 x 3	7/11	13 x 10 x 2½	9/9
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10 x 4 x 2½	6/4	11 x 8 x 2½	8/3	12 x 10 x 3	10/3
9 x 7 x 2	6/6	10 x 8 x 3	8/6	15 x 10 x 2½	10/6
12 x 4 x 2½	6/10	13 x 8 x 2½	8/10	17 x 10 x 2½	11/3
9 x 8 x 2½	7/6	12 x 9 x 2½	8/11	17 x 9 x 3	11/6
10 x 8 x 2½	7/10	14 x 7 x 3	9/6	17 x 10 x 3	12/3

The above are sizes for which we have most demand, but we can also make other sizes to order (at a small extra charge) within the following limits:—
Depths 1in., 1½in., 2in., 2½in. and 3in. only.
Maximum length 17in.
Minimum width for 3in. depth is 5in.
Minimum width for 2½in. depth is 4in.
Minimum width for 2in. depth is 3½in.
Minimum width for 1½in. depth is 3in.
Minimum width for 1in. depth is 2in.
We cannot undertake to make odd shapes, extra bends, lips, etc.
To arrive at the approximate cost of a special size of chassis take the nearest standard size above and add 2/6.

PANELS

We can also supply the aluminium for use as panels, screens, etc., cut to any size up to 3ft. by 3ft. at 4/- per square foot.

NOTE.—A panel cannot be sent through the post if the length plus twice the width exceeds 6ft.

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Direct reading, wide range, outstanding value

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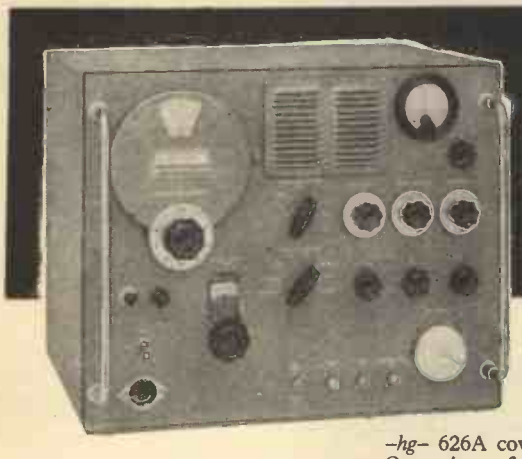


NEW! -hp- 626A/628A shf Signal Generators

10 to 21 KMC, 10 mw output

SWR 1.2, high accuracy

No calibration charts

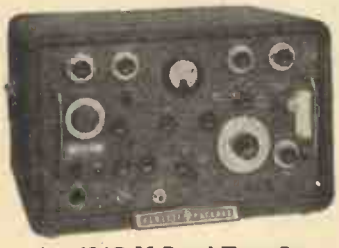
Pulse, FM, square wave modulation

New –*hp*– 626A/628A are the first commercial signal generators to bring the wide range, high power, convenience and accuracy of lower-frequency signal generators to the 10 to 21 KMC range. –*hg*– 626A covers frequencies 10 to 15·5 KMC; –*hp*– 628A, 15 to 21 KMC. Operation of the instruments is typical of –*hp*– generators. Frequencies are directly set and read on one dial. No calibration charts are required. Output voltage is directly set and read. Output is 10 to 20 db better than previous spot-frequency generators. SWR is better than 1·2 at 0 dbm and lower. Internal pulse, FM or square wave modulation is provided, together with facilities for external pulsing or FM'ing. –*hp*– 626A, $3,250.00. –*hp*– 628A, $3,000.00.

Typical-*hp*-signal generators

-*hp*- 608D vhf Signal Generator

-*hp*- 612A uhf Signal Generator



-*hp*- 624C X Band Test Set

* Rack mounted instrument available for $15.00 less

OTHER -*hp*- SIGNAL GENERATORS

Instrument	Frequency Range	Characteristics	Price
–*hp*– 608C	10 to 480 Mc	Output 0·1 μv to 1 v into 50 ohm load. Pulse or CW modulation. Direct calib.	$950.00
–*hp*– 608D	10 to 420 Mc	Output 0·1 μv to 0·5 v. Incidental FM less than 0·001% entire range.	$1,050.00
–*hp*– 612A	450 to 1,200 Mc	Output 0·1 μv to 0·5 v into 50 ohm load. Pulse, CW or square wave modulation. Direct calibration.	$1,200.00
–*hp*– 614A	800 to 2,100 Mc	Output 0·1 μv to 0·223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calib.	$1,950.00
–*hp*– 616A	1,800 to 4,000 Mc	Output 0·1 μv to 0·223 v into 50 ohm load. Pulse, CW or FM modulation. Direct calib.	$1,950.00
–*hp*– 618B	3,800 to 7,600 Mc	Output 0·1 μv to 0·223 v into 50 ohm load. Pulse, CW, FM or square wave modulation. Direct calibration.	$2,250.00
–*hp*– 620A	7,000 to 11,000 Mc	Output 0·1 μv to 0·223 v into 5 ohm load. Pulse, FM or square wave modulation.	$2,250.00
–*hp*– 623B	5,925 to 7,725 Mc	Output 70 μv to 0·223 v into 50 ohm load. FM or square wave modulation. Separate power meter and wave meter section.	$1,750.00
–*hp*– 624C	8,500 to 10,000 Mc	Output 3·0 μv to 0·223 v into 50 ohm load. Pulse, FM or square wave modulation. Separate power meter and wave meter section.	$2,265.00*

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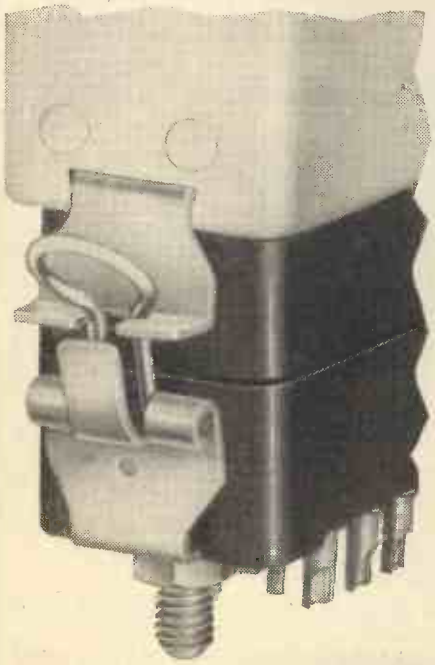

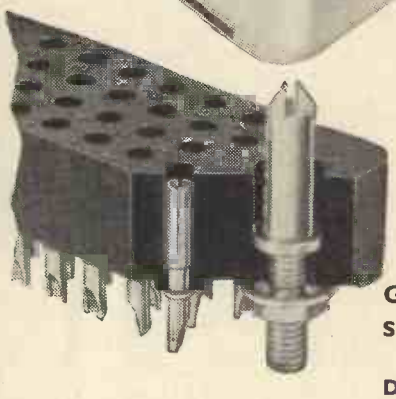

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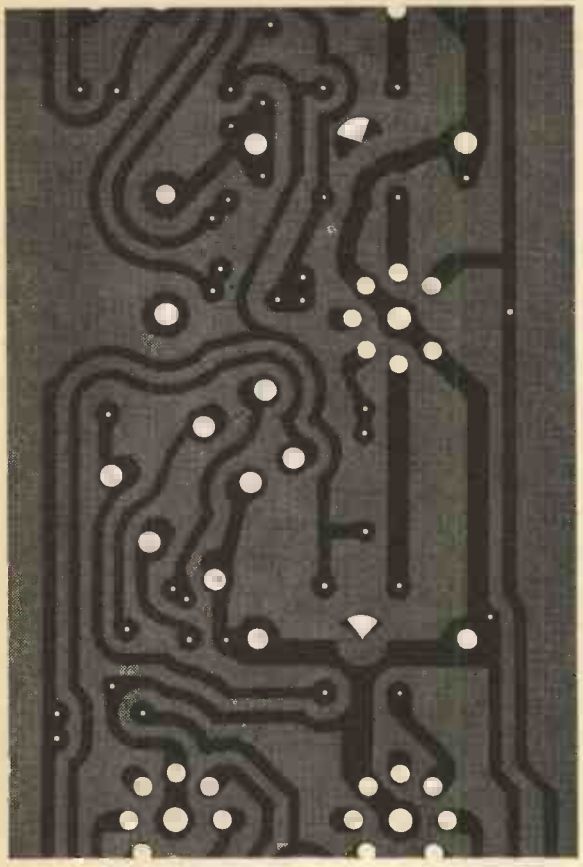

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- *Very high ohmic value.*
- *Tolerances from ± 25% down to ± 0.1%.*
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- *Comprehensive range available.*
- *Also standard range including probably the world's smallest layer resistor.*

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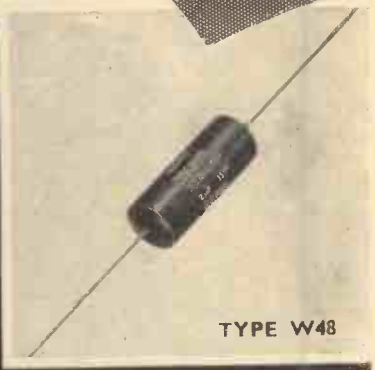
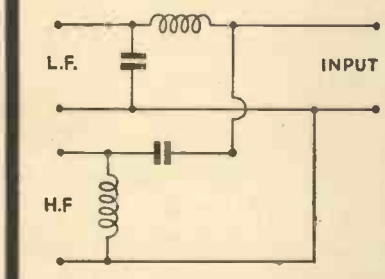
Hunts patented Metallised Paper Capacitors are particularly suitable for loudspeaker crossover networks and are used extensively for this application. They have negligible self inductance with consequent lack of self resonance within the audio frequency range, and with the special method of end connections used on the capacitor unit, the equivalent series resistance down to zero applied volts is extremely low.
The capacitors listed below are considerably smaller in dimensions than conventional types, occupying only 25-30% of the space required for their lowest voltage counterparts in foil and paper construction.



TYPE W48



A basic circuit for a twin speaker combination is shown on the left. The number of circuit elements and their capacitance and inductance values depends on the number of loudspeakers, their individual characteristics, and the required crossover frequencies.

TYPE W54/1

STANDARD CAPACITANCE RANGE

LIST NO.	CAP μF	VOLTS D.C. Wkg.	TYPE REF.	DIMENSIONS L D	LIST PRICE
A 316	1.5	150	W48	1⅞" × 11/16"	4/9
A 304	2	150	W48	1⅞" × 11/16"	5/-
B 557	3	150	W49/1	1⅞" × ¾"	7/6
B 550	4	150	W49/1	2⅛" × 1"	10/-
B 551	6	150	W49/1	2½" × 1"	12/6
B 552	8	150	W49/1	2½" × 1⅜"	17/6
WP 45	10	150	W54/1	2⅛" × 1⅜"	20/-
WP 38	12	150	W54/1	2⅛" × 1⅜"	22/-
WP 247	16	150	W54/1	3¼" × 1⅜"	26/6

TYPE W49/1

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And in Canada: HUNT CAPACITORS (Canada) LTD. AJAX, ONTARIO
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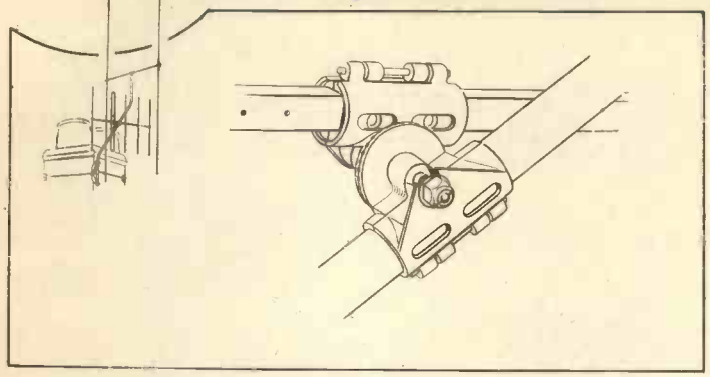
'360' ADD-ON AERIALS
WITH FULL ORIENTATION



Fitted in seconds for any angle any direction.

The Wolsey "Add-on" aerials, incorporating the new '360' clamp can be mounted in apposition to the stand-off arm and provide unlimited orientation in every direction.

Available in

BAND III aerials, 3, 5 and 8 elements and BAND II aerials, "H" type and Yagi 4.

NOTE THESE PLUS FEATURES

1 360 degrees orientation in all 3 planes irrespective of angle of stand-off arm.
2 Can be supplied to fit stand-off arms or masts $\frac{7}{8}$", 1" or $1\frac{1}{8}$" (please specify when ordering).
3 Attaches aerial direct to stand-off arm or mast thus eliminating unnecessary sag (no extra arm required).
4 Attaches by hinged collar to stand-off arm or mast in seconds (no dismantling necessary).
5 Locks positively at any angle, in any situation by the tightening of *one* non-slip nut.

AND NOTE THESE RETAIL PRICES

Band III Types	VHF/FM Types Band II
360/Y3 . . . . 27/6	360/FMH 50/-
360/Y5 . . . . 40/-	360/FMY4. . . . 65/-
*360/Y5WS. . 42/6 (Wide spaced)	
360/Y8 . . . . 55/-	

When ordering: Suffix 'A' for $\frac{7}{8}$" dia. Suffix 'B' for 1" dia. Suffix 'C' for $1\frac{1}{8}$" dia.

*A chimney-lashed wide-spaced 5 element Yagi incorporating a '360' clamp is also available (Y5WSL, price £3.10.0 retail).

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W39

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HIGH VOLTAGE TEST SET

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Height 17½in. by length 20in. by width 12½in.

WEIGHT 34 lb.

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Continuous and smoothly variable from zero to 2,500 volts by means of continuously variable regulating transformer.
The test voltage is applied smoothly without high stress from voltage surges.

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A miniature magnet circuit breaker in the primary circuit and double pole on-off switch with double pole mains fuses provide perfect protection.

VOLTMETER
A high-grade instrument connected in the primary circuit but scaled to read output voltage.

2.5 KV at 500 VA
INSULATION TEST SET
Price £40.8.6
Complete with test prods.

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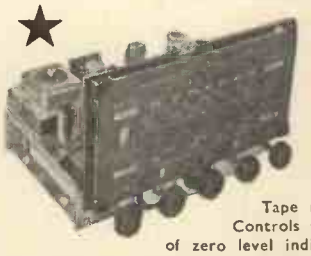
Dulci MODEL H.II TUNER CHASSIS (AM/FM)
aptly described as . . .
. . . "THE HEART OF HIGH FIDELITY"



A COMBINED AND SELF-POWERED Tuner, Control Unit and Audio Pre-amplifier covering every requirement of the connoisseur of the higher sense of sound. Precise equalisation for every input channel. F.M. (VHF), Long, Medium and Short wavebands. Switched also for L.P. and 78 r.p.m. records and Tape replay. Graded Bass and Treble Controls with 15 db lift and cut each side of zero level indication. Every section of this comprehensive equipment is designed for optimum performance.

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D.P.A.10 (10-14 watts) Main Amplifier £12 12 0
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G.A.4 (4 watts) with neat Control Panel size 6in. x 4in. on fly leads with separate Bass and Treble Controls. Frequency range 40-15,000 c.p.s. Selector switch for Tuner and Gram channels. (78 r.p.m. and L.P.) ... £9 9 0
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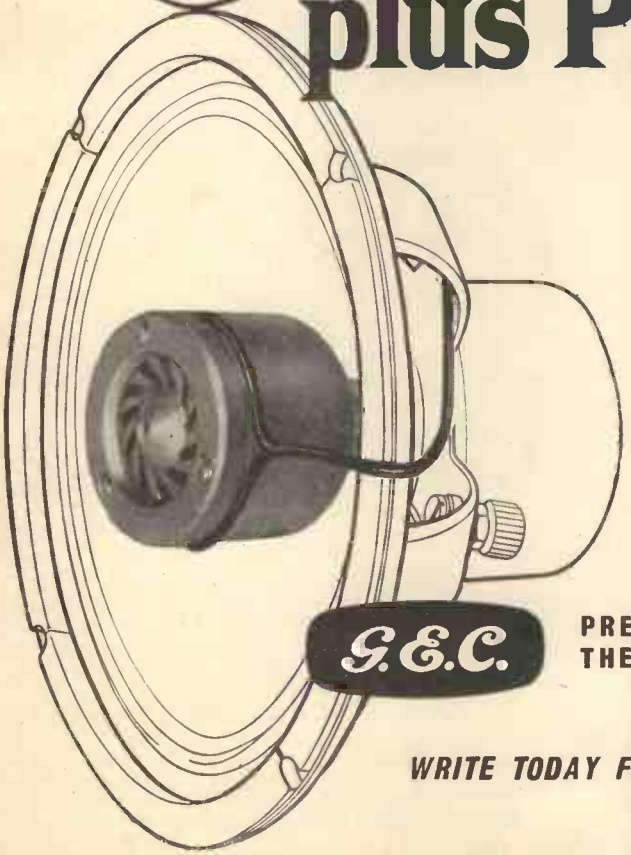

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Taking advantage of the exceptional bass performance and smooth response of the metal cone loudspeaker, this unit adds "presence" to the reproduction of music—brings the sound right into the room with you. Specially designed as an accessory to the loudspeaker, it's a music lover's "must".

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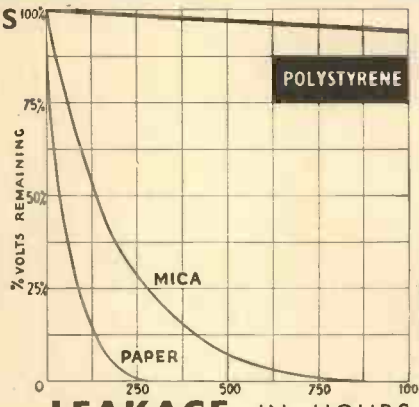

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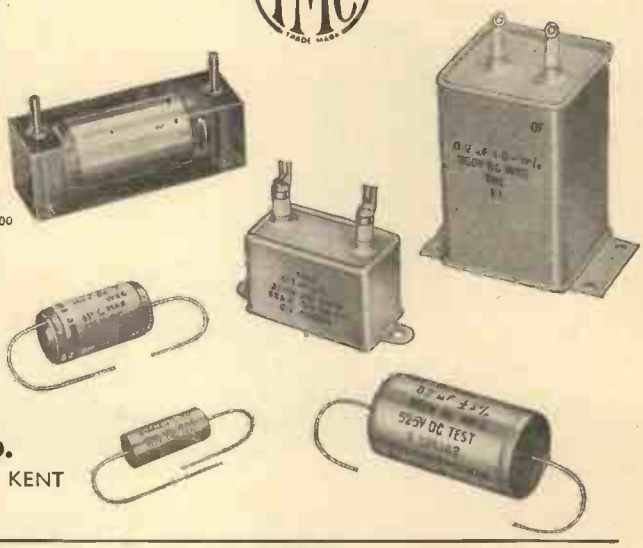

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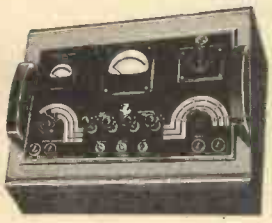
Precision Oscilloscope L140

The type L.140 Oscilloscope provides a laboratory standard for pulse analysis. Time and voltage measurements are clearly displayed on direct reading illuminated scales conveniently positioned on either side of the 5″ C.R.T. The long term measuring accuracy is within 3% of the quantity measured from 1.5μs to 150ms and from 300mV to 300V (4% down to 10mV).

The Y amplifier is direct coupled for sensitivities from 150mV to 300V/cm peak to peak and has a rise time of 0.05μs.

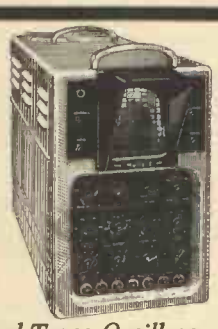
For sensitivities between 4.5mV and 150mV/cm the amplifier is a.c. coupled (useful frequency range 5c/s to 10Mc/s) and has a rise time of 0.06μs.

Signals are applied to a high impedance probe with variable backing-off facilities so that selected portions of the input waveform can be expanded for examination.



Transistor Tester L264

The Mullard Transistor Tester has been developed to provide a rapid means of checking general characteristics and ascertaining if a transistor has been damaged in circuit. Facilities for measuring the important parameters, α, base-collector short-circuit current gain, as well as $I'_{C(O)}$ and the collector turnover voltage are provided. Although designed as a simple testing unit, it has an accuracy of ±5%.



Dual Trace Oscilloscope L101/2

This high grade, general purpose instrument incorporates two identical amplifiers with sensitivities of 20mV/cm over a bandwidth of 4Mc/s. Voltage measurements (±5%) and time measurements (±10%) are by null methods. The time base may be free running or triggered, and sweep speeds are from 0.1μs/cm to 10ms/cm.

Precision Pulse Generator L141

The pulse generator type L.141 provides two main pulses with accurately controllable amplitude, duration, p.r.f., and separation, together with additional pulses for triggering or synchronising.

The amplitude of the two main pulses is continuously variable between 300μV and 100V, their duration from 0.5 to 100μs, and the separation between them from 0 to 100ms.

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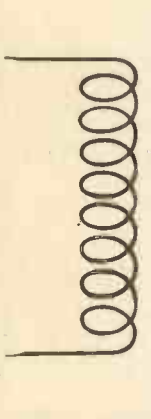

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COLLIN'S T.C.S. 6, 9, 12, 13. Complete equipment:—Transmitter, Receiver, Rotary Converter (12 v.), Remote Control, Aerial Coupling Unit, Microphone, Key and Connecting Cables.

MULTI-CHANNEL TRANSMITTER T-4/FRC, with modulators MD-1/FRC, 2 Mc/s to 18 M/cs. Each channel 400 w. output.

W.S. No. 19 & 22. Both complete with installation kit. Tropicalised.

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62 TRANSCEIVERS complete.

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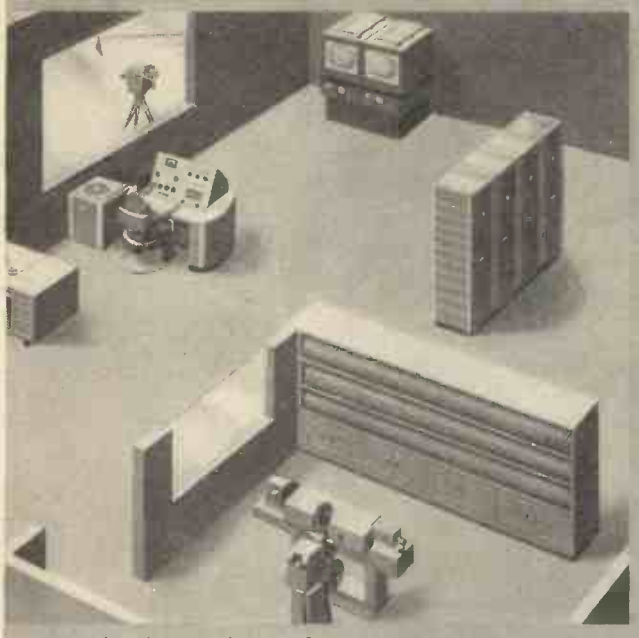
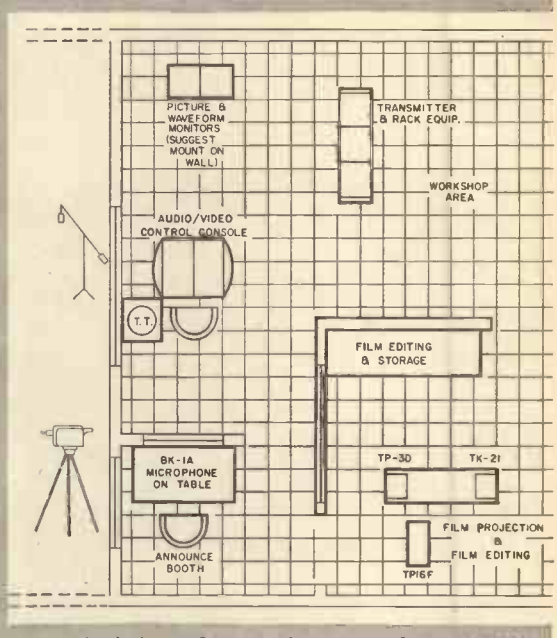
provides complete facilities for versatile programming with minimum investment



Centralized Control Room for Basic Station



Typical Floor Plan—scaled in one foot squares

EQUIPMENT "PACKAGE" for basic TV station consists of an RCA vidicon film camera chain, picture and waveform monitoring facilities, 16-mm film projector, slide projector, multiplexer, studio synchronizing generator, master audio-video switching console, stabilizing amplifier, turntable, microphone, transmitter, antenna, audio editing equipment, spare parts, installation tools and materials.

A complete television broadcasting "package", comprised of equipment basic to all television stations, is offered by RCA to those planning television broadcasting on a small but highly efficient scale. The Basic Television Station enables the broadcaster to start programming with a relatively small investment, and reduces operating costs to the minimum.

All units in the "package" meet RCA's world-famous standards of good engineering for high quality performance. Proved and tested in the field, this equipment assures continuous, dependable service with minimum operating and maintenance personnel. The Basic Television Station offers many important advantages:

ECONOMICAL ONE-MAN OPERATION . . . One man can easily operate all program controls which are located in the unique two-section Audio-Video control and switching console. The operator of this centralized control can also handle any additional live and film cameras that might be added later.

PROGRAMMING VERSATILITY . . . The RCA Basic TV Station provides facilities for: Network or incoming "off-air" satellite programs; local 16-mm programming; local film and slide programs; local live programming.

EASILY EXPANDED . . . "Matched" design permits quick and easy expansion—without obsoleting the basic equipment. "Matched" live camera and remote pickup facilities can be added when desired; or an increase in power can be made at a later date with RCA "Add-On" Amplifiers or higher power transmitters.

See your RCA Distributor for additional information on the RCA Basic Television Station. Or write Dept. TV49C, RCA International Division, Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y., for free booklet giving complete details.

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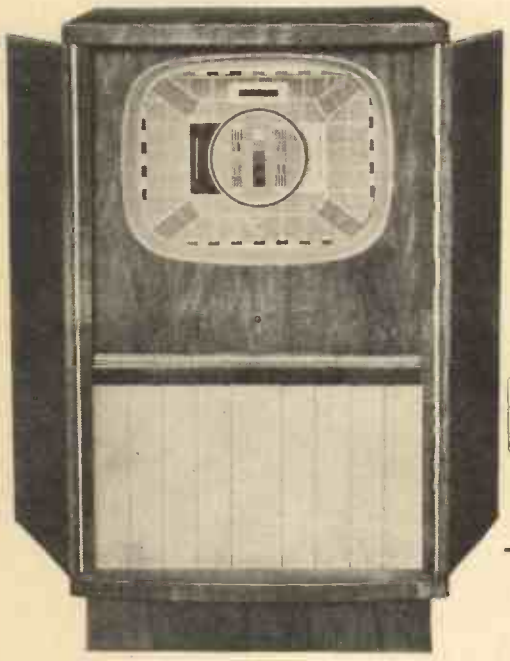

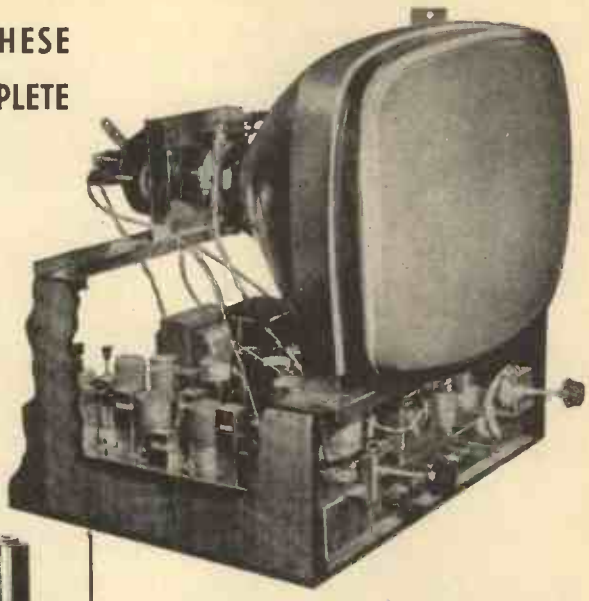

These Televisors use a double wound mains transformer which gives you complete safety from contact with the mains supply when handling the chassis or controls

CONSOLE CABINETS with full length doors for 14in., 16in. and 17in. tubes PRICE £14/14/-. H.P. Terms: Deposit £7/7/6 and 9 monthly payments of 18/6. CONSOLE CABINETS. Half door, previously advertised, still available at £12/12/-. H.P. Terms: Deposit £6/6/- and 8 monthly payments of 18/3.
On above cabinets add 21/- for pkg. and carr.

★ **B.B.C. & I.T.A. DESIGN No. 1 with NEW TURRET TUNER**
MAY BE BUILT FOR £33-7-11 PLUS COST OF C.R.T.

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★ Amplifier may be used for gramophone or microphone purposes giving high-quality reproduction.
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★ Complete with reel of Scotch Boy Tape (1,200ft.), and spare reel.
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£5 DEPOSIT & 8 MONTHLY PAYMENTS OF £4.18.6 or CASH PRICE £40 plus 21/- pkg. & carr.

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3-SPEAKER SYSTEM

Consists of Speakers W12CS, Bronze 10CSB, Super 3HF and a special Crossover Unit fitted into a very attractive Cabinet, size 34in. × 31in. × 12in. Weight 60 lb. Cash £39/10/-. Credit deposit £5/0/0 and 8 monthly payments of £4/17/-, or H.P. deposit £19/15/- and 12 monthly payments of £1/16/8. Packing and carriage 21/-.

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At £6/4/- is a high efficiency pressure driven reproducer covering 2,500 c.p.s. to 16 kc/s. It makes an excellent 2-speaker system when used with the Axiom 150 Mark II at £10/15/9. A special Crossover Unit type X05000 is available at £1/19/-. The complete system £18/18/9 cash. Credit terms deposit £2/7/9 and 8 monthly payments of £2/6/6, or H.P. Terms deposit £9/9/4 and 11 monthly payments of £1/1/-. Packing and carriage 7/6.

THE NEW TSL FM TUNER HIGH STABILITY MODEL

6 Valves including Magic Eye and Power Supply using the latest type Gorler permeability Unit complete with first audio stage and preset output volume control. Maximum radiation less than 10 microvolts per metre. Sensitivity better than .5 microvolts. Cash price £17/10/- (inclusive) or on H.P. terms, deposit £8/15/- and 9 monthly payments of £1/1/8. Credit terms deposit £2/3/9 and 8 monthly payments of £2/3/4. Postage and packing 5/- extra.

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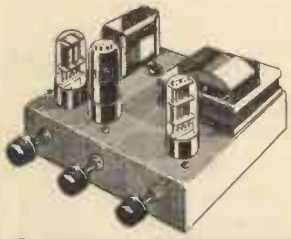
MULLARD AMPLIFIER KIT

NOW SUPPLIED WITH ULTRALINEAR OUTPUT TRANSFORMER.

All the components for model 510, PLUS pre-amplifier on one chassis (total six valves) chassis gold hammer finished. May be purchased for £12/12/- plus pkg. & post 7/6, or pre-amplifier and tone control in a separate unit £14/14/- plus pkg. and post 7/6.



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Instruction Book 1/- post free.

A steel case is now available, complete with engraved panel, for 15/6 extra. The amplifier may be supplied complete for £5/5/- plus pkg. and post 3/6, or fitted in case at £6 plus pkg. and post 3/6. Engraved panel 3/6. Post Free.

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The famous Premier Baby Alarm which is device to enable Baby's cries, or even breathing, to be heard in any selected room in the house. May be left permanently connected. Extra Microphones in different rooms may be used. The microphone may be positioned up to 100ft from the main unit. Suitable flexible lead can be supplied at 5d. per yard extra.

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Completely wired and tested at **90/-** Plus 2/6 post and pkg

2-BAND TRF RECEIVER MAY BE BUILT FOR £5.15.0

plus pkg. & post 3/-

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MAY BE BUILT FOR **£7 . 19 . 6** Plus 3/- Pkg. & Postage

These two receivers use the latest type circuitry and are fitted into attractive cabinets 12in. × 6½in. × 5½in. in either walnut or ivory bakelite or wood. Individual instruction books 1/- each, post free.

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MAY BE BUILT FOR **£7 . 8 . 0** Plus 3/- Pkg. & Postage

4 Miniature valves in a super-het circuit covering medium and long waves, Rexine-covered cabinets 11¼in. × 10in. × 5¼in., in two contrasting colours, wine with grey panel Instruction book 1/6 post free, which includes full constructional details and list of priced components.

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PRE-AMPLIFIER & TONE CONTROL UNIT

Available completely constructed, £5/5/- plus 2/6 packing and postage.

PREMIER BUREAU DE LUXE

A superb cabinet in finely figured walnut veneer. Interior light sycamore, with rexine matching lining Overall dimensions: 33in. high, 34in. long, 17¼in. deep. Uncut control panel on right hand side approximately 16in. × 10¼in., uncut baseboard on left hand side 15½in. long, 13½in. deep. Two full size felt-lined storage cupboards in the lower part of the cabinet.

Cash price 16½ gns. H.P. Terms, deposit £8/13/6 and 12 monthly payments of 16/1.

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SPECIAL OFFER!

GOODMANS AUDIOM 50. £4/17/6 plus packing and postage 5/-.

THE WOLSEY BAND III CONVERTER

This converter has been designed to receive alternative programmes on Band 3 Channels 6 to 13, selection of Channel being made by rotation of Switch Knob. Mains supply 200/250 v. A.C only. The high gain of this Converter (minimum 20dB) together with low noise factor ensures good picture quality. A variable gain control makes it possible to balance a Band 1 and Band 3 signal inputs to the receiver. Any single channel Receiver of either T.R.F. or Superhet design may be fed from the Converter. Separate input sockets are provided for Band 1 and Band 3 inputs. Cash price £9/19/6. Credit Terms deposit £1/5/6 and 8 monthly payments of £1/5/6. IMPORTANT, please state your Band 1 station. Packing and postage 3/- extra.

207, EDGWARE RD., LONDON, W.2. Tel: Ambassador 4033 & Paddington 3271

PREMIER RADIO COMPANY

PORTABLE TAPE RECORDER CABINETS

All Rexine Covered

Tape Deck	Amplifier	Type	Price
Lane Mk. VI	Premier	Mk. VI	£4 19 6
Lane Mk. VI	Premier	de Luxe	£4 19 6
Truvox Mk. III	Truvox C	T.D.3	£4 4 0

Plus Postage and Packing 5/-.

BARGAIN OFFER

LATEST TYPE RUBBER ESCUTCHEON SUITABLE FOR 17in. RECTANGULAR TUBES AT A SPECIAL PRICE OF 10/-. PLUS PACKING AND POST 1/6.

THE NEW COLLARO TAPE TRANSCRIPTER

SPEEDS 3¾, 7½ & 15 inches per Second £20 plus pkg./post 7/6

We carry a comprehensive stock of components by all leading manufacturers.

CABINETS—PORTABLE

MODEL PC/2

Grey Lizard Rexine covered 45/-

Overall dimensions 15in. × 15in. × 6in. Clearance under lid when closed 3in.

MODEL PC/2 DE LUXE

Two colours, wine and grey, with cutout for speaker and amplifier 55/6

Dimensions as above.

MODEL PC/3

Grey Lizard Rexine covered 69/6

Overall dimensions 16¼in. × 14½in. × 10¾in. Clearance under lid when closed 6¼in.

MODEL PC/3 DE LUXE

As above but with cutouts for Speaker and Amplifier 79/6

Dimensions as above.

THE ABOVE CABINETS ARE COMPLETE WITH CARRYING HANDLE FASTENERS AND PANEL.

Packing and Postage 3/- each.

Junction Transistors 10/- each
Equivalent of the OC70 Type

A RANGE OF BAND 3 AND F.M. AERIALS IS NOW AVAILABLE

Air spaced co-axial wire, 1/9 per yard.

Teletron Ferrite Rod Aerials. Medium Wave 8/9. Medium Long Wave 12/9.

PREMIER VARIABLE IMPEDANCE "MATCHMAKER" M.O.15 OUTPUT TRANSFORMERS

Designed to meet the demand for an efficient variable ratio output Transformer, 11 ratios from 13 : 1 to 80 : 1, all centre tapped and can be used to match any output valves either single or push-pull. Class "A," "AB1," "AB2" or "B" to any low impedance speech coil or combination thereof. Primary Inductance 50 henries 15 watts audio 100 mA. Price 45/-.

PREMIER MAINS TRANSFORMERS

All primaries are tapped for 200-230-250 v. mains 40-10 cycles. All primaries are screened.

SP175B, 175-0-175, 50 mA., 4 v @ 1 a., 4 v. @ 2-3 a.	15/-
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SP351A, 350-0-350, 150 mA., 4 v. @ 2-3 a., 4 v. @ 3-6 a., 4 v. @ 1-2 a., 4 v. @ 1-2 a.	30/-
SP352 350-0-350 150 mA., 5 v. @ 2-3 a., 6.3 v. @ 2-3 a. 6.3 v. @ 2-3 a.	30/-
SP425A, 425-0-425, 200 mA 6.3 v. @ 2-3 a., 6.3 v. @ 3-5 a., 5 v. @ 2-5 a.	52/6
250-0-250, 80 mA. 6.3 v. @ 4 a., 5 v. @ 2 a.	22/6
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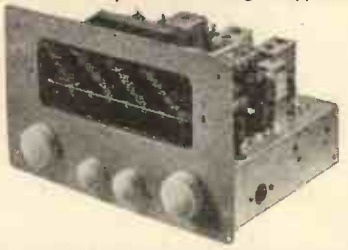

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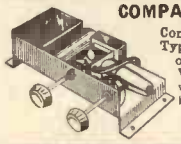

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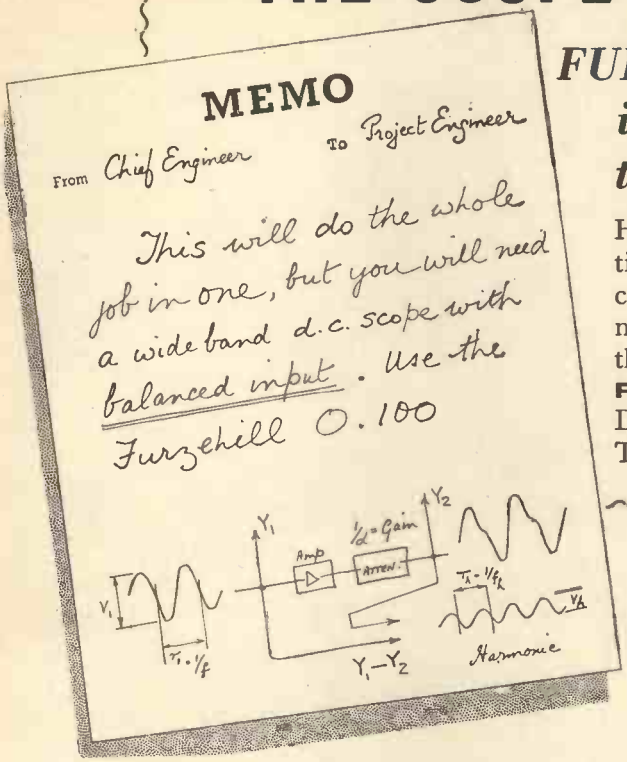
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MARCH 1957

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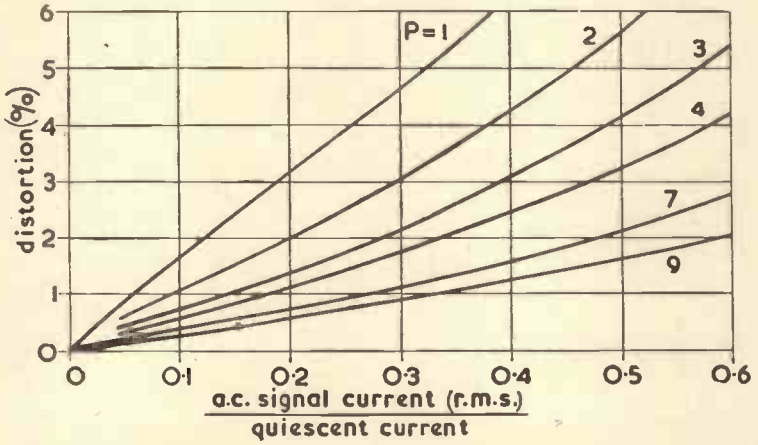
Distortion in Transistor Amplifiers

In high quality amplifiers, low distortion is essential. Hence a knowledge of the causes of distortion in transistor amplifiers, the means of estimating distortion and reducing it should prove extremely useful. The following account includes a brief analysis of distortion in low level transistor stages and a graph from which distortion in OC70 and OC71 stages can be obtained.

Causes of Distortion

In a transistor amplifier operated with grounded emitter, distortion results from two causes. First, for a sinusoidal voltage input the input current is non-sinusoidal because of the intrinsic non-linearity of the voltage-current characteristic of the emitter junction. This is the input circuit distortion. Second, for a sinusoidal current input to the base, the collector current is non-sinusoidal due to variation of the collector-to-base current gain (β) with the collector current. The distortion due to the latter is normally small and can usually be neglected.



Input Circuit Distortion

The input characteristic consists of two parts: that of the base-emitter junction itself and that of the part of the base between the junction and the soldered connection. The voltage-current relationship of the semiconductor junction is exponential: $i \propto e^{v}$.

The effective incremental resistance of the junction r_{exp} at the working point, as seen from the base is given by the formula

$$r_{exp} = \frac{25}{I_e}\beta \text{ ohms},$$

where I_e is in milliamps.

The base resistance $r_{bb'}$ is however nearly ohmic and approximately equal to 450Ω in the OC70 and OC71 for values of I_e between 0.5 and 5mA. The main component of distortion produced by the non-linearity of the junction characteristic is second harmonic (D_2) and only this is considered.

It can be shown that distortion is proportional to the ratio of the r.m.s. signal current to quiescent current, and inversely proportional to 1 + ratio of total ohmic resistance to r_{exp}. i.e.

$$D_2 \propto \frac{i_{e\,(r.m.s.)}}{I_e} \quad \text{and} \quad \frac{1}{D_2} \propto 1 + \frac{R_b + r_{bb'}}{r_{exp}}$$

where R_b is the external input circuit resistance. These two relations give the variation of distortion with circuit and operating conditions. The accompanying graph shows actual values of distortion plotted against the ratio of r.m.s. emitter signal current to quiescent emitter current at I_e = 2mA for several values of a parameter P which is the ratio of total ohmic resistance to exponential resistance in the input circuit.

$$P = \frac{R_b + 450}{r_{exp}} = \frac{(R_b + 450)\,I_e}{25.\beta}$$

The graph may be applied without serious inaccuracy to OC70 and OC71 stages operating at I_e = 0.5 to 5mA and the input circuit distortion can therefore be derived from it for all likely practical amplifiers.

Distortion due to Current Gain Variation

The collector-to-base current gain varies with the collector current (I_c), but this variation is small over the operating range; the gain reaching a maximum at about 1.5mA for an OC71.

When the operating point is at the current for maximum gain, distortion due to β variation will be negligible. Provided that I_c is kept above 0.2mA the effect of β non-linearity is small and may add to or subtract from the input circuit distortion, depending on whether I_c is less than or greater than the value giving maximum β. The amount of distortion can be estimated from the transfer characteristic by conventional methods. Thus the accompanying table gives the amount of second harmonic distortion corresponding to the ratio of the amplitude of the two half-cycles of the output waveform.

Ratio	1.01	1.02	1.04	1.08	1.16
D_2%	0.25	0.5	1	2	4

Emitter Feedback

When an external series emitter resistance R_e is used to linearise the characteristic, its effect is equivalent to the addition of an external base resistance of value $R_e\beta$. Thus the graph can still be applied provided that the value of P is calculated from the formula

$$P = \frac{R_b + \beta R_e + 450}{r_{exp}}$$

Emitter feedback also reduces the distortion due to variation in current gain.

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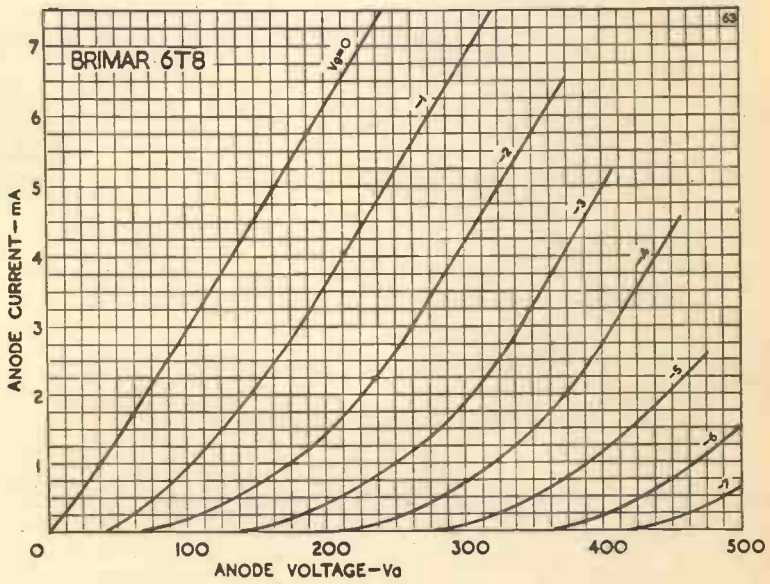

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Typical Triode Operating Characteristics as an R.C. coupled amplifier.

Anode Supply Voltage	250	250 volts
Anode Load Resistor	0.25	0.25 megohms
Grid Resistor...	1.0	10 megohms
Cathode Bias Resistor	3	0 kilohms
Peak Output Voltage	43	40 volts
Stage Gain (for 24 V peak to peak output) ...	42	42
Distortion (for 24 V peak to peak output) ...	1	5%

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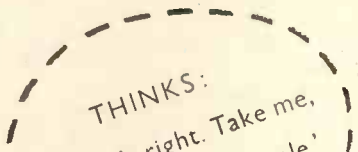

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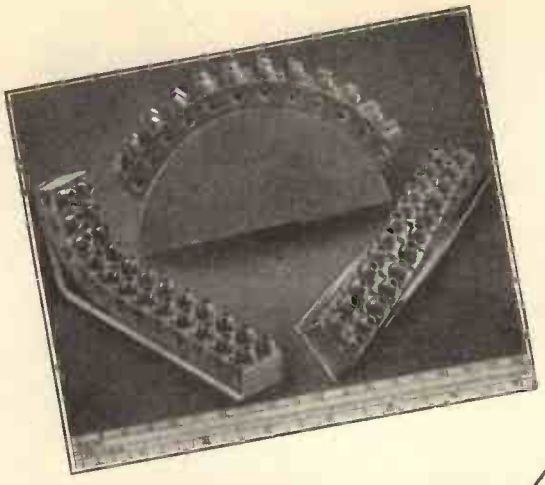

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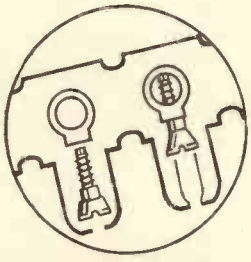

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A very narrow pattern is certainly advantageous under extreme fringe conditions where everything must be accomplished for gain and to reduce interference coming from the sides and the rear.

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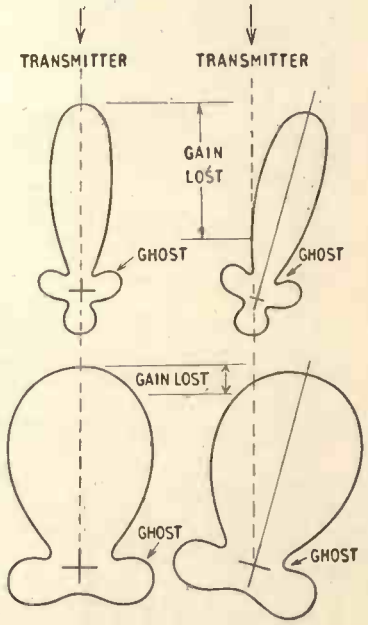

A useful hint when reading the response pattern of a V.H.F. aerial.

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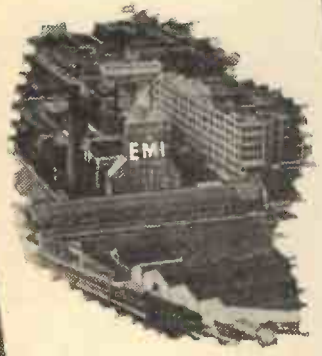

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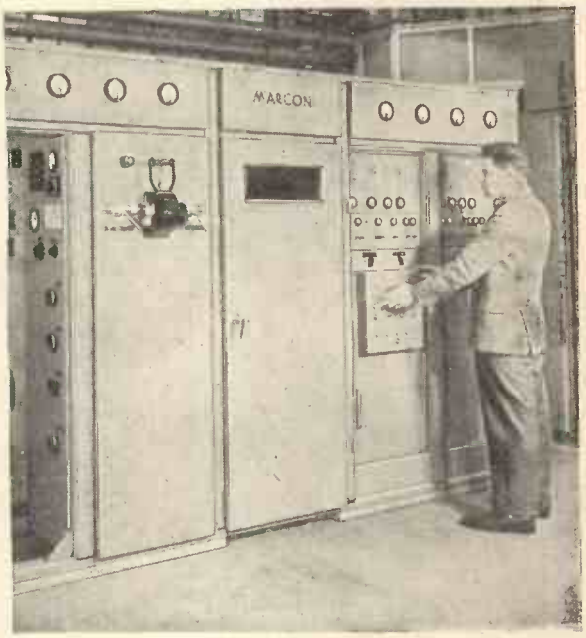
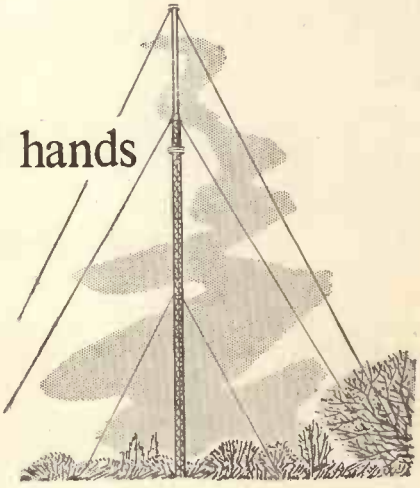
—Part of "His Master's Voice", Marconiphone, etc., etc.

From microphone to aerial



through Marconi's experienced hands

In the surge of new television requirements, Marconi's have not forgotten that the majority of countries still look to them first and foremost for the supply, installation, maintenance and, in some cases, operation of sound broadcasting systems. Moreover, television programmes are not silent; sound broadcasting equipment and techniques must advance in step with vision. The unique experience and advanced technical knowledge of Marconi's are at the disposal of broadcasting authorities all over the world.



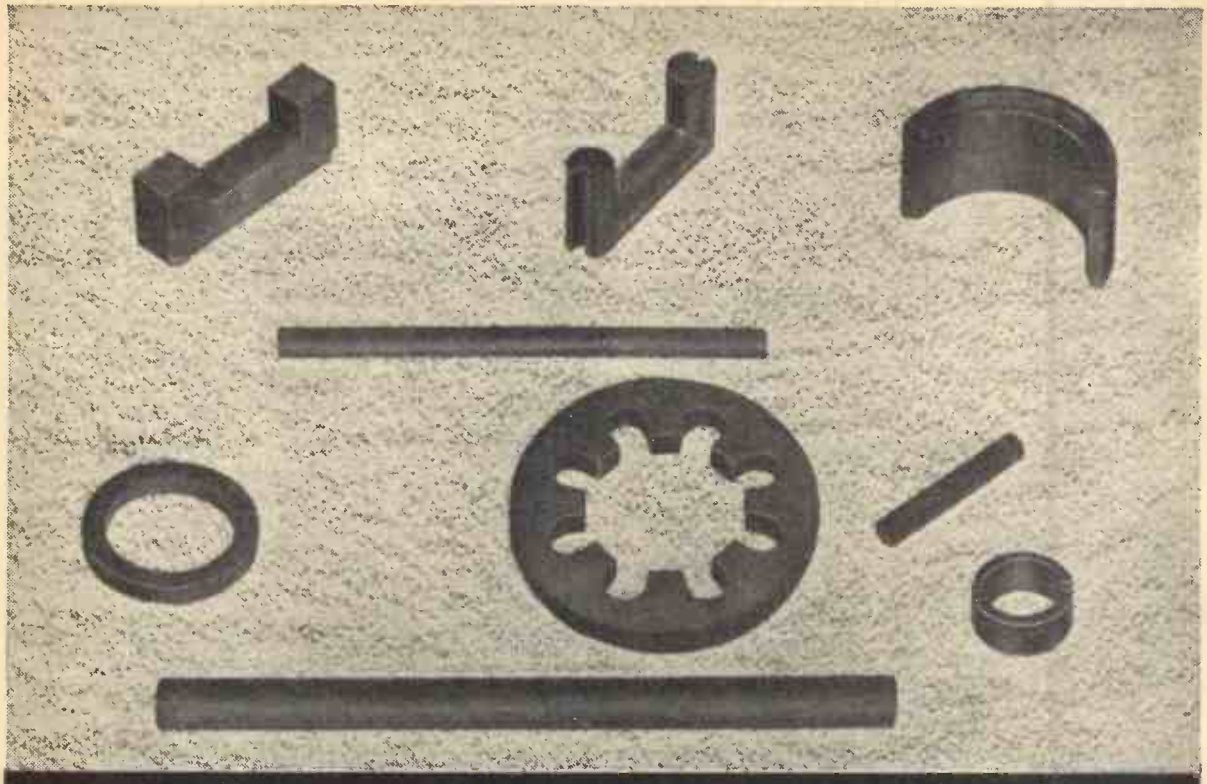
75% of the world's broadcasting authorities rely on Marconi Equipment.
Marconi Television equipment is installed at all B.B.C. and I.T.A. Television Stations.

Lifeline of Communication

MARCONI

Complete Sound and Television Broadcasting Systems

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX
LB 7



Keeping pace with electronic progress ... Plessey ferramic materials

Ferramic (Regd.) ferrites are available in several grades—each grade having its own particular applications:

Ferramic NW6 and NW10

Ferramic NW6 rods used in radio receivers in place of conventional frame aerials, give increased efficiency in extremely compact form. NW6 was developed primarily for long and medium wave use, whilst NW10 has had its useful working range extended up to 20 Mc/sec. Both have particularly good stability and temperature coefficient.

Ferramic NW1

This low loss material for frequency range 1 kc/sec to 500 kc/sec is particularly suitable for high Q coils where high stability of inductance is important. Available in various sizes of pot cores and supplied in either rod or tube form.

Ferramic NW8

This grade with its high saturation flux density, high maximum permeability and low losses is well suited for use as line output transformer cores for T.V. applications. Special shapes and sizes are available for 90° angle tubes. The material is also available in the form of rods or conventional E-cores.

Electrical Design Engineers are invited to request data sheets dealing with these and other products from:—

CHEMICAL AND METALLURGICAL DIVISION
THE PLESSEY COMPANY LIMITED · WOOD BURCOTE WAY · TOWCESTER · NORTHANTS
Tel. Towcester 312

PC8

E·M·I

ELECTRONIC TACHOMETERS
for ACCURATE speed measurement

TACHOMETER TYPE 2

- **Covers most requirements for speed measurement**
- **Frequency measurement 2 c/s to 20,000 c/s in 4 ranges (Accuracy better than 2%)**
- **Inputs either photo-electric probe or voltage pulses**

By using the photo-electric or other suitable transducers the instrument will measure any rotational speed desired. An output is available to allow the use of the instrument in conjunction with a pen or other similar recorder.

TACHOMETER TYPE 1

- **Designed for the precise measurement of shaft speeds. Can be readily adapted to measure velocity, length, pressure, flow, etc.**
- **Accuracy is to within 1 part in 10^4 over range 40-40,000 pulses per sec.**

The tachometer counts the number of impulses occurring during a pre-set period of 1, 2 or 4 secs., displaying total on 4 dekatron valves. Count (max. 9,999) held for 0.5 secs when counting period is 1 second and for 1 second when period is 2 or 4 seconds. Totals automatically cleared and counting recommences. Also 'manual' press button operation.

This instrument is designed to operate with any suitable type of Transducer such as the E.M.I. Photo-electric Transducer Type 1B.

OTHER PRODUCTS

ELECTROMAGNETIC VIBRATORS (with associated control equipment up to 3,000 lb. thrust) · PHOTO-ELECTRIC TRANSDUCERS · STROBOSCOPES · DYNAMIC BALANCERS H.F. HEATERS

For full information contact :—

E.M.I. ELECTRONICS LTD. INDUSTRIAL PRODUCTS DIVISION (DEPT. 18C)

HAYES · MIDDLESEX · ENGLAND Tel: SOU 2468 Ext 473

Part of the E.M.I. Group . . . Britain's Foremost Electronic Engineers

1E65

F

High quality, stable characteristics, robust construction, proven performance, are inherent features of the quartz crystal units developed and manufactured by S.T.C.

Crystals in hermetically sealed cans to meet the rigid Inter-Service specification; crystals in evacuated glass envelopes with wire ends or with valve base; G.T. Cut crystals for absolute frequency standards; high frequency Overtone crystals for V.H.F. applications . . . these are the principal types in the S.T.C. range.

There is almost certain to be an S.T.C. quartz crystal unit to meet your specification . . . if not, our engineers are ready to discuss your special requirements.

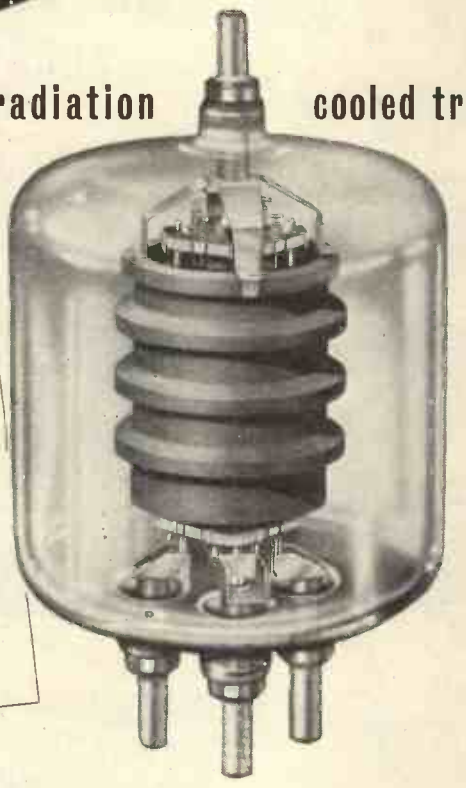
The quartz crystal units illustrated are in hermetically sealed cans equivalent to the Inter-Service Style "D" or the American HC6U. This unit has been widely adopted for use in modern equipments.

Standard Telephones and Cables Limited

Registered Office : Connaught House, Aldwych, W.C.2

QUARTZ CRYSTAL FACTORY: HARLOW · ESSEX

A new radiation cooled triode



Specially designed for Industrial R.F. heating equipment

TENTATIVE CHARACTERISTICS

V_f	10 volts
I_f	18 amps
V_a Max	5 kV
Max. operating frequency at full rating	40 Mcs.
μ	40
g_m	8 mA/V

The Ediswan ES.1001 is a radiation-cooled triode with rugged graphite anode and thoriated tungsten filament designed specially for use in Industrial R.F. heating equipment.
Its maximum anode dissipation is 1 kW, but being radiation-cooled no complicated cooling arrangement is required although an air flow is needed when the valve is used at full ratings.

Further information available on application

A forced air cooled triode with thoriated tungsten filament and with a maximum anode dissipation of 12 kW at 40 Mcs. will also be available shortly.

EDISWAN

INDUSTRIAL AND TRANSMITTING VALVES

THE EDISON SWAN ELECTRIC COMPANY LIMITED 155 Charing Cross Road, London, W.C.2 & branches
Phone: Gerrard 8660 *Member of the A.E.I. Group of Companies* *Grams: Ediswan, Westcent, London*

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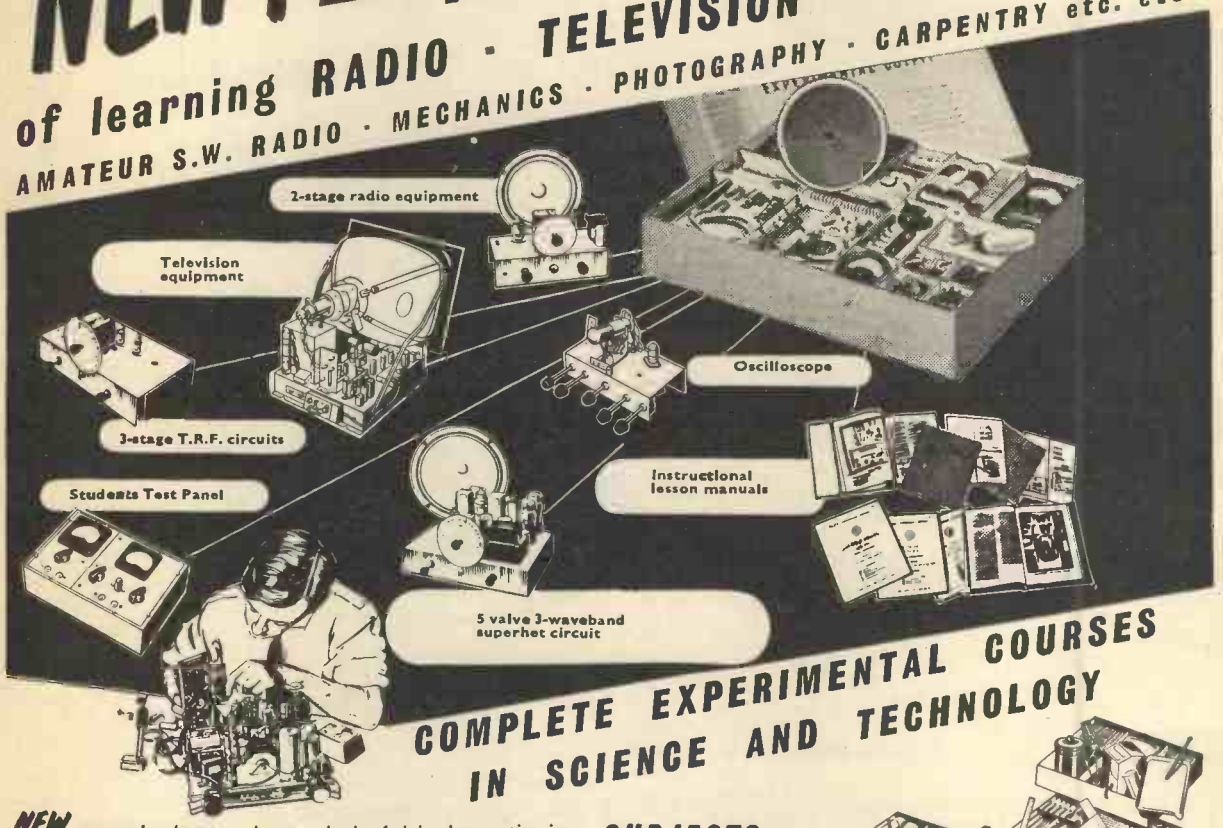

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I am interested in the following subject(s) with/without equipment

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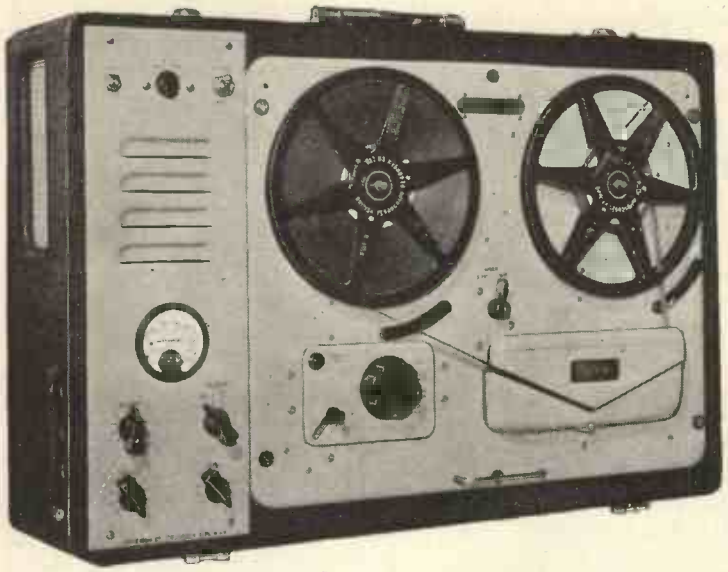
MARCH *We shall not worry you with personal visits* ICSS

EMI INSTITUTES

– Part of "His Master's Voice", Marconiphone, etc., etc.

Vortexion TAPE RECORDER



★ The total hum and noise at 7½ inches per second 50-12,000 c.p.s. unweighted is better than 50 dbs.

★ The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

★ A lower bias lifts the treble response and increases distortion. A high bias attenuates the treble and reduces distortion. The normal setting is inscribed for each instrument.

★ The distortion of the recording amplifier under recording conditions is too low to be accurately measured and is negligible.

★ A heavy mu-metal shielded microphone transformer is built in for 15-30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load. This is equivalent to 20ft. from a ribbon microphone and the cable may be extended 440 yds. without appreciable loss.

★ The .5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.s, microphone or radio inputs.

★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

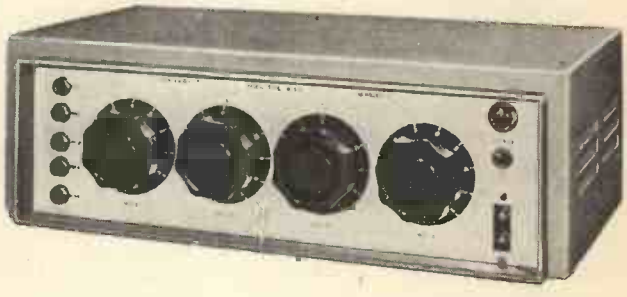
★ The power output is 3.5 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

★ The play back amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

★ The unit may be left running on record or play back, even with 1,750ft. reels, with the lid closed.

FOUR CHANNEL ELECTRONIC MIXER

is almost essential for the professional or semi-professional where a number of different items have to be mixed on one tape recording.
It is recommended by a number of tape recorder manufacturers for this purpose.
Any normal input impedance can be supplied to order, balanced or unbalanced, the standard being 15-30 ohms balanced.
The normal output is 0.5 volt on 20,000 ohms or more, but 600 ohms is available as an alternative.
The steel stove enamelled case is polished and fitted with an engraved white panel suitable for making temporary pencil notes.
An internal screened power pack and selenium rectifier feed the five low noise non-microphonic valves.
Used in many hundreds of large public address installations and recording studios throughout the world.



Manufactured by

VORTEXION LIMITED, 257-263, The Broadway, Wimbledon, London, S.W.19

Telephones: LIBerty 2814 and 6242-3 Telegrams: "Vortexion, Wimble, London."

WESTON
PORTABLE
INSTRUMENTS

Weston Portable Instruments include D.C. moving coil, A.C. rectifier and H.F. thermocouple types, and instruments of the A.C./D.C. moving iron type; high grade dynamometer models are also available.

Illustrated above is the Model S.82—a permanent magnet, moving coil instrument in the Portable range. This is primarily a Precision Grade instrument but can also be supplied with Industrial Grade accuracy. Details of this Model, together with others in this series, are available on request.

SINGLE PHASE AND POLYPHASE
WATTHOUR METERS
SYNCHRONOUS TIME SWITCHES
SYNCHRONOUS MOTORS
AND MOTOR UNITS

SANGAMO WESTON

PANEL & SWITCHBOARD INSTRUMENTS
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D.C. Moving Coil, A.C./D.C. Dynamometer

CURRENT TRANSFORMERS · FREQUENCY METERS · ALL-PURPOSE TEST SETS AIRCRAFT INSTRUMENTS · RATIOMETERS TACHOMETERS · WESTON STANDARD CELLS · ELECTRICAL THERMOMETERS "PHOTRONIC" PHOTO ELECTRIC CELLS PHOTOMETERS

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sw/2s

When you buy a tape recorder your choice will be governed by two factors—

PRICE AND SPECIFICATION

The best tape recorder won't be cheap—but it will be good value for money.

The Grundig 'Specialist' TK.820/3-D is the best value for your money. Its presentation, its versatility, its performance, its push-button track changeover, makes it the only possible choice for so many people. Provided the machine has the facilities, appearance and ease of control you demand, it remains to check whether or not its specification will stand up to your requirements.

Here is the complete technical specification of the TK.820/3-D. Read it critically—and write to us if there is anything else you would like to know.

GRUNDIG Makers of the finest tape recorders in the world.

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Advertising Dept. & Showroom :
39-41, NEW OXFORD STREET, LONDON, W.C.1
Sales Dept. & Works :
KIDBROOKE PARK ROAD, LONDON, S.E.3.
(Electronics Division, Gas Purification & Chemical Co. Ltd.)

GRUNDIG 'SPECIALIST'

Mains voltage: suitable for A.C. only, 105 – 115, 190 – 210, 210 – 230, 230 – 250 volts, 50 cycles. Power Consumption: approximately 90 watts maximum. Mains Fuses: 2 amps (for 105 – 115 volts), 1 amp (for 190 – 250 volts). H.T. fuses: 500 m/A Surge Resisting, 120 m/A Surge Resisting. Valve line-up: EF 86, ECC 81, EL 84, EL 42, EM 71 + 2 metal rectifiers. Mains tapping panel and fuses instantaneously available. Two tape speeds — 3¾ ins/sec and 7½ ins/sec: speed change instantaneous by electrical means – heavy duty dual speed split phase induction motor: recording time (with 1,200 feet recording tape) 2 × 30 minutes at 7½ ins/sec – 2 × 60 minutes at 3¾ ins/sec: half track recording, track change without spool reversal: track changeover by press button approximately 2 seconds. Trackbutton remains down to indicate which track was played last: frequency range 50 – 9,000 cycles at 3¾ ins/sec, 40 – 14,000 at 7½ ins/sec: noise is down at least 40 dBs and wow and flutter less than 0.3% at 7½ ins/sec, less than 0.5% at 3¾ ins/sec.

Automatic stop foil at end of spools: fast forward and fast rewind time approximately two minutes per full spool. Illuminated precision place indicator: recording level meter by 'magic eye', tone control for treble or bass emphasis.

Loudspeakers: elliptical high-flux permanent magnet moving coil + two 2½ inch tweeters. Special four-position speaker control. Connections for low impedance extension speaker and high impedance external amplifier remote controls, earphones. Microphone, diode and radio input sockets.

Overall dimensions: 17 inches × 17½ inches × 9½ inches. Weight approximately 48 lb.

Retail Price **98 gns.**

GD273

Britain's finest Hi-Fi Equipment . . .

It was in 1945 that H. J. Leak revolutionised the performance standards for audio amplifiers by designing the original "Point One" series, and we became the first firm in the world to market amplifiers having a total distortion content as low as 0.1 per cent. This claim was received with incredulity, but it was subsequently confirmed by the National Physical Laboratory and since then hundreds of TL/12 amplifiers have been used by the B.B.C., and Commonwealth and foreign broadcasting authorities, and thousands have been used by recording studios, leading musicians and music-lovers throughout the world.

Further development work resulted in our producing, at a much lower price but with the same high performance standards, the TL/10 amplifier. The output of the TL/10 is ample for high fidelity home music systems, and the quality of reproduction obtained is equal in every respect to that of the TL/12. We always use the TL/10 amplifier and "Point One" pre-amplifier for our public demonstrations of high fidelity reproduction of gramophone records and radio. The TL/10 amplifier, when used with the best available complementary equipment, gives to the music-lover a quality of reproduction unsurpassed by any equipment at any price. Even when the complementary equipment falls below that of the best obtainable the use of these amplifiers will enable one to obtain very marked improvements in reproduction.

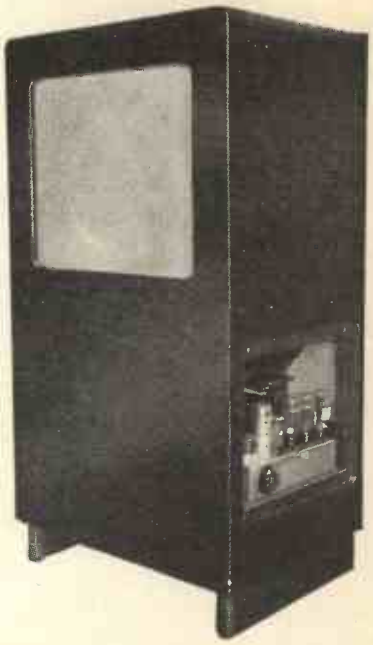
The

B.B.C. MONITOR LOUDSPEAKER UNIT

uses a

LEAK TL/12 AMPLIFIER

Price £28.7.0



We shall be pleased to send you full details of

LEAK

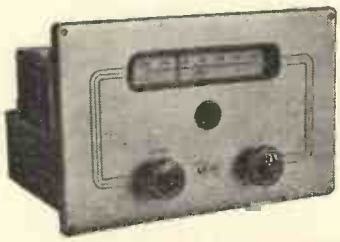
HIGH FIDELITY EQUIPMENT

Below:

LEAK TL/10 10-watt Amplifier, 17gns. and "Point One" Pre-amplifier, 10gns.

Prices made possible only by world-wide sales

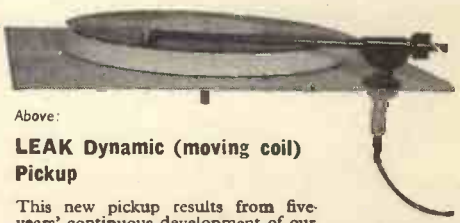
Harmonic Distortion 0.1% 1,000 c/s, 7.5 watts output.



On Left:

LEAK TROUGH-LINE F.M. Tuner, £25 plus 10 gns. P.T.

A Trough-line inductor and AFC eliminate drift. Very high sensitivity for fringe area listening. Quieting control plus high fidelity discriminator. Cathode-follower output. Self powered to operate with any amplifier.



Above:

LEAK Dynamic (moving coil) Pickup

This new pickup results from five years' continuous development of our first moving-coil design. Reports from users have justified our earlier belief that the pickup might earn recognition as the best in the world.

Leak dynamic pickup: Arm ...	£2.15.0	p.t. £1.3.1
LP head with diamond stylus	£5.15.0	p.t. £2.8.4
78 head with diamond stylus	£5.15.0	p.t. £2.8.4
Mumetal cased transformer...	£1.15.0	

The first name in High Fidelity . . .

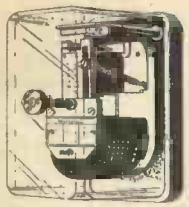
LEAK

CREL is the trade name of the Leak Full-range Electrostatic Loudspeaker which will be available to the public in 1957. The design is original and has great theoretical and practical advantages over previously described electrostatic loudspeaker systems. It is the result of intensive research and development work carried out by H. J. Leak, M.Brit.I.R.E., and A. B. Sarkar, M.Sc., who are the authors of a paper, describing the basic design principles of this loudspeaker, which was published in the "Wireless World," October 1956. A reprint of this paper will be supplied on request.

H. J. LEAK & CO. LTD., BRUNEL ROAD, WESTWAY FACTORY ESTATE, ACTON, W.3, ENGLAND

Telephone: SHEpherds Bush 1173/4/5 *Telegrams: Sinusoidal, Ealux, London* *Cables: Sinusoidal, London*

OVERCURRENT RELAY



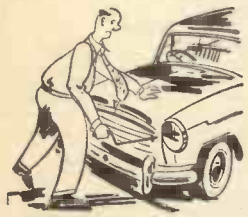
Beautifully made by the famous American Westinghouse Company. These are the surface through panel type with clear Pyrex glass covers. They have coils for remote push button resetting.
Type A—calibrated for currents between .1 and .4 amps.
Type B—calibrated for currents between .5 and 2 amps.
Price, unused and perfect, £3/17/6 each.

CIRCUIT DETAILS

Diagrams and other information extracted from official manuals. All 1/6 per copy, 12 for 15/-.

American Service Sheets	R.109
A.1134	76 receiver
BC.348	R28/ARC5
BC.312	R1116/A
R.103A	RA-1B
B,C.342	AR88D
RA-1B	AN/APA-1
R-208	78
R-1155	76
R-1124A	R.T.18
R-1132A/R-1481	CAY-46-AAM-
R-1147	RADAR
R-1224A	A.S.B.-3.
R-1082	Indicator 62A
R-1355	Indicator A.S.B.3
B.C.1206-A/B	Indicator 62
B-455-A (or -B)	Indicator 6K
B-454-A (or -B)	R.F. unit 24
B-453-A (or B)	R.F. unit 26
Transmitter T1154/ B.D.J.N.	R.F. unit 25
	R.F. unit 27
Fifty-eight walkie-talkie	Wireless set No. 19
Frequency meter B.C.221.	Demobbed valves

DON'T BE CAUGHT LIKE THIS



CAR STARTER CHARGER KIT

All parts to build 6- and 12-volt charger which can be connected to a "flat" battery and will enable the car to be started instantly. Kit comprising the following.

Mains transformer	22/6
5-amp. rectifier	17/6
Regulator Stud Switch	3/6
Resistance Wire	2/-
Resistance Former	2/6
Mains on/off Switch	2/6
0-5 amp. Moving Coil Meter	12/6
Construction Data	1/6

or if bought all together price is 62/6, plus 2/6 post and packing.

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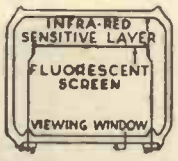
These are complete fluorescent lighting fittings. Built-in ballast and starters—stove enamelled white and ready to work. Ideal for the kitchen, over the workbench and in similar locations.

Single 40. 4ft. 3in. long, uses a 40 watt tube. Price 39/6 complete with tube. Carriage and ins. 5/6.

Twin 20. Uses 2 20-watt standard tubes. Price 29/6 less tubes. Carriage and ins. 4/6.

FREE THIS MONTH

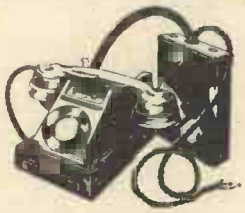
To all "Wireless World" readers who send S.A.E. we will present free a copy of our booklet:—
"MAKING AN ELECTRIC BLANKET"



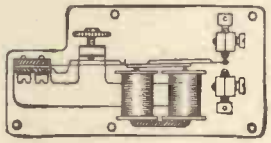
"SNIPER-SCOPE"

"Cats eye" used for seeing in the dark. Will work burglar alarms, counting circuits, smoke detectors and the hundred and one other devices as will the simpler type of photo cell. Price 5/- each. Post and ins. 1/-. Data will be supplied with cells if required.

OFFICE TELEPHONES



New G.P.O. telephone sets with internal bell and push button switch easily connected together to form office intercom. Price £2/10/- each. Post, etc., 2/6.

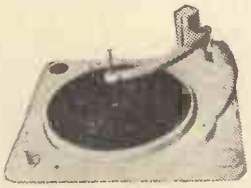


HIGH SPEED RELAY

This is a miniature type relay. with change-over platinum contacts. Bobbins are 250 ohms each. Brand new—7/6 each, post 1/6. 6 post free.

MINIATURE MOTOR

Size only 2½in. long by 1½in. diameter. American made, laminated poles and armature, intended for 28 volt D.C. but O.K. on lower D.C. voltages and A.C. mains, through step-down transformer. Price 10/6. Post, etc., 2/-.



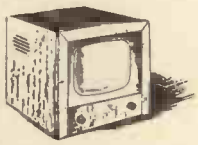
Sent for 30/-

4-SPEED & 3-SPEED GRAMOPHONE AUTO-CHANGER

Latest types by all famous makers are invariably in stock at competitive prices. B8R Monarch, Garrard, etc. Latest models from £8/10/-, or deposit £1/10/- and 8 payments of £1 plus 5/- carriage and insurance.

The "ESTRONIC" BAND III CONVERTER

To-day's best value in Band III converters suitable for your T.V. or money refunded. Complete ready to operate, 59/6 non mains or 85/- mains, post and insurance 3/6.

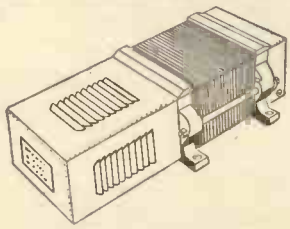


14" T.V. CABINET

14in. T.V. cabinet of the latest styling made for one of our most famous firms—beautifully veneered and polished—limited quantity—19/6 each. Carriage and packing 3/6 extra.

CONSTANT VOLTAGE TRANSFORMERS

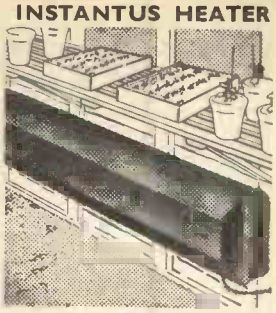
Made by the famous Advance Company, all brand new and unused. Specification: Type No. MTZ 267U, input 85-110 volts, 50 c.p.s., output 350 volts R.M.S. output current .83 amps.
Price 37/6 each. Carriage and insurance 5/-.



EX-ROYAL NAVY SOUND POWERED TELEPHONE

These require no batteries and will go for long periods without attention. Complete with generator and sounder which gives a high pitched note easily heard above any other noise. Also fitted with an indicator lamp which in quiet situations can be used instead of the sounder, or where several telephones are used together, will indicate which one is being called. Size 7½ × 9 × 7½in., wall mounting, designed for ships' use but equally suitable for home, office, warehouse, factory, garage, etc. Price 57/6 each, plus 4/6 carriage.

INSTANTUS HEATER



Convector heater, 1 kW. rating, 4ft. long, made from heavy gauge sheet steel (galvanised). Can be used for greenhouse, workshop, aviary, etc., etc. Price £2/10/-, or with thermostat, £4/5/-, carriage 5/-. GUARANTEED 5 YEARS.

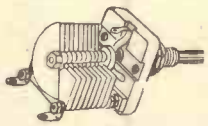
MULTI-SPEED MOTOR

Works off A.C./D.C. mains; fitted with gear box, gives any speed from 1 r.p.m., 22/6, post and packing 1/6.

POCKET TRANSISTOR RECEIVER

All the parts to build cigarette box receiver, £2/17/6, includes Ferrite aerials but not the earpiece, battery or case.

FINE TUNERS



Ceramic trimmers all with ¼in. spindle of fair length. 5, 10, 15, 30, P.F. at 2/3 each or 24/- per dozen.

WESTINGHOUSE (U.S.A.) METERS

All moving coil flush mounting type, outside diameter of face 3½in.

0-500 v. D.C.	25/-
0-1.5 kV D.C. external multiplier	35/-
0-2.5 kV D.C. external multiplier	35/-
0-15 v. A.C.	30/-
0-1 mA.	25/-
0-50 mA.	25/-
0-100 mA.	25/-
0-150 mA.	25/-
0-250 mA.	25/-
0-500 mA.	25/-

THERMAL DELAY SWITCH

Hermetically sealed with 4-pin base, heater resistance approx. 1,500 ohms. This can be used for overload protection. Approximately 17 milliamps through the heater coil will cause the contacts to close. Useful for many applications such as delaying anode volts until the heaters are properly warmed up. Limited quantity—7/6 each, post and insurance 1/6. 6 post free.

INDUSTRIAL OVERHEAD HEATER

This overhead heater warms only the area within its radiant rays, and so effects a considerable saving of fuel. Its benefits are felt immediately, there is no warming-up period. It is essentially a personal type of heater, having controls within easy each of the operative. The controls give four variations of heat and "Off." At maximum heat the unit consumes 1 kW.

The Infray Major is of particular use:—

(a) In large rooms, warehouses, lofts, machine shops, etc., where the cost of heating the whole room to a comfortable level would be too great.
(b) In rooms which in the main have to be kept cool, e.g., food storage chambers, beer cellars, etc.
(c) In any situation where local heating is required quickly.

Price is £7/10/-, carriage paid.

ELECTRIC BLANKET WIRE

Waterproof P.V.C. covered, so blanket washable, 16½ ohms per foot—1/6 per yard. 14 yards, ideal for average blanket, £1, post free.

MINIATURE COMPONENTS

Made by Fortiphone and other famous firms. Intervalve transformers N22 10/-, N23 10/-. Push-Pull input transformer A203, 15/6. Push-pull output transformer A204, 15/6. Earphone, 250 ohm, L, 18/-. Plastic Eartip, 2/9. Tinsel leads and plug for earphone. 5/-. Slide switch ref. SW5, 4/-. Pots with switch, ½ meg., 2/-. Very small resistors, many values, 6d. Very small condensers, prices from 6d. Tinsel leads without plug, 6d. Deaf aid cases with clip for pocket, 2/6. Plastic box with lid, 4½ × 3in. × 1½in., 2/6.

F.M. TUNER

This tuner is based upon the very successful circuit in the booklet published by Data Publications. We have made up models at all branches and will be glad to demonstrate. Cost of all parts including valves, prepared metal chassis, wound coils and stove enamelled scale, slow motion drive, pointer, tuning knob, in fact everything needed to make the complete unit, is £8/12/6. Data is included free with the parts or is available separately, price 2/-.

THE UNI—T.V.

Undoubtedly the most up-to-date televisor for the home constructor. You can build all or only part and the set when finished will be equal to a factory made equivalent. What other constructor T.V. has all these features?

- Made up units if required
- All miniature valves
- Metal rectifier
- No expensive transformers
- 13-channel circuitry
- Multi-vibrator time bases
- Ferrox cube, E.H.T. and scan coils
- 34/38 mc/s. I.F.
- Suitable for any modern 12, 14 or 17in. tube
- Modern contemporary cabinet if required

The building cost (less tube) is only £29/10/- plus 10/- carriage and insurance. All parts guaranteed twelve months. Full information and data free with parts or available separately, price 3/6.

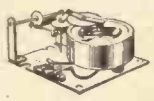
THE "CRISPIAN" BATTERY PORTABLE

A 4-valve truly portable battery set with very many good features as follows:

- **Ferrite Rod Aerial.**
- **Low consumption valves (DK96 range).**
- **Superhet circuit with A.V.C.**
- **Ready built and aligned chassis if required.**
- **Beautiful two-tone cabinet.**
- **Guaranteed results on long and medium waves anywhere.**

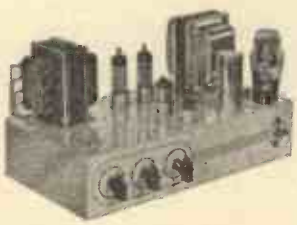
All parts, including speaker and cabinet, are available separately or if all ordered together the price is £7/15/- complete. Post and insurance 3/6. Ready built chassis 30/- extra. Instruction booklet free with parts or available separately 1/6.

METER MOTORS



These are very small A.C. mains operated motors which have many applications for driving toys or other light loads. All are in good condition, but not new, having been stripped from electric light meters. Final speed of approx. 1 rev. per hour.
Price 8/6 each. Post and insurance 2/-.

THE MULLARD 510 AMPLIFIER

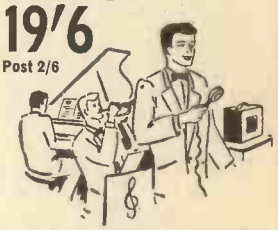


A High Quality Amplifier designed by Mullard engineers. Robust high fidelity with a power output exceeding 10 watts and a harmonic distortion less than .4% at 10 watts. Its frequency response is extremely wide and level being almost flat from 10 to 20,000 C.P.S.—three controls are provided and the whole unit is very suitable for use with the Collaro Studio and most other good pick-ups. The price of the unit completely made up and ready to work is £12/10/-, plus 10/- carriage and insurance. Alternatively, if you wish to make up the unit yourself we shall be glad to supply the components separately. Send for the Mullard amplifier shopping list.

MINI-RADIO

Uses high-efficiency coils—covers long and medium wavebands and fits into the neat white or brown Bakelite cabinet—limited quantity only. All the parts, including cabinet, valves, in fact, everything, £4/10/-, plus 3/6 post. Constructional data free with the parts, or available separately, 1/6.

19/6
Post 2/6



Powerful three-valve Mains amplifier, ideal for dances, parties, etc. Complete less chassis cabinet and speaker (available if required)—data 1/6 (free with parts).

T.V. Commercialising Outfit

DO IT YOURSELF IT'S REALLY QUITE EASY

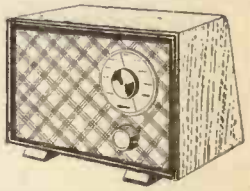
You will manage it in an evening and we guarantee

SUCCESSFUL RESULTS OR MONEY BACK

Our parcel contains: *I.T.A. Aerial, 36ft. I.T.A. Down Lead, I.T.A./B.B.C. Interference Eliminator, I.T.A. Converter.* A special bargain price for all the above items if bought together is £8/10/-. Or £1/10/- down and 8 monthly payments of £1. Post and ins. 4/6. Full details with illustrations 1/6.

THE SKYSEARCHER

An all mains set for 19/6



This is a 2-valve plus-metal rectifier set useful as an educational set for beginners, also makes a fine second set for the bedroom, workshop, etc. All parts, less cabinet, chassis and speaker, 19/6. Post & ins. 2/6. Data free with parts or available separately 1/6. 3-valve battery version also available at the same price.

TRANSISTORS

Red spot replace Mullard OC71, etc. 10/-. Blue spot suitable R.F. up to 1.6 Mc/s 15/- each. Mullard OC71, 20/-. OC72, 30/-.

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All enquiries to Eastbourne address and please enclose S.A.E., terms are cash with order.

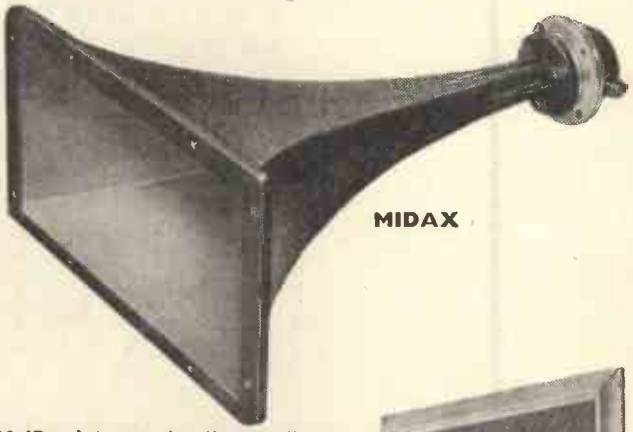
25-WATT 3-WAY HIGH FIDELITY LOUDSPEAKER SYSTEM

TREBAX

This system comprises specially designed components which, used together, form a magnificent reproducer having very low distortion with wide frequency range, and generous power handling capacity. Each loudspeaker unit is a "specialist" for its own part of the musical register, so that the overall design does not suffer from compromises such as are necessary with a single unit "wide range" loudspeaker. The extreme flexibility of this system enables its performance to be adjusted accurately to individual requirements.

The TREBAX High Frequency Pressure Driven Unit is a precision instrument covering the treble register from 2,500 c/s to 16,000 c/s, with absolute freedom from irregularities in response. It incorporates a unique self centering diaphragm assembly which can be replaced without the use of special equipment. To allow for the overlap region with the mid-range unit the crossover point should be placed at 5 Kc/s.

The MIDAX Mid Range Pressure Driven Unit covers the middle register from 400 c/s to 8 Kc/s with very low distortion. Crossover points should be placed at 750 c/s and 5 Kc/s to allow proper overlaps with bass and treble units. Special features include the use of an easily replaced self centering diaphragm assembly and a robust casting for the horn.



MIDAX

AUDIOM 80

The AUDIOM 80 (Bass) is a 15 in. direct radiator bass unit, of the massive construction and with the design refinements so necessary for absolute reliability and freedom from distortion under full load conditions. The crossover point to the mid range unit should be placed at 750 c/s. The Audiom 80 (Bass) Unit employs a cast chassis, with a plastic treated diaphragm suspension.

For optimum bass performance the Audiom 80 (Bass) loudspeaker should be housed in an enclosure loaded by an **Acoustical Resistance Unit (Type 280).** The construction of such an enclosure is extremely simple. The Midax and Trebax Units may be housed in the same enclosure, provided due allowance is made for the volume which they occupy.

280 ARU

Crossover networks should be of the half section type, with 15 ohm terminations. 750 c/s, Type XO/750; 5000 c/s, Type XO/5000

Goodmans

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Canadian Agents:
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WW/2/57

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a new Mumetal Shield for the 4" Emitron Cathode Ray Tube type 4 E.P.I.

This Shield has been designed with the assistance of Electronic Tubes Ltd., and is now fully tested and approved to produce maximum magnetic screening.

The Shield is manufactured in two halves in 0.036" thick Mumetal and is attractively finished with silver hammer stove enamel exterior and matt black heat absorbing interior.

Dimensional drawings are available on request.

Provided that additional tooling is unnecessary slight modifications can be effected to the screen at little extra cost.

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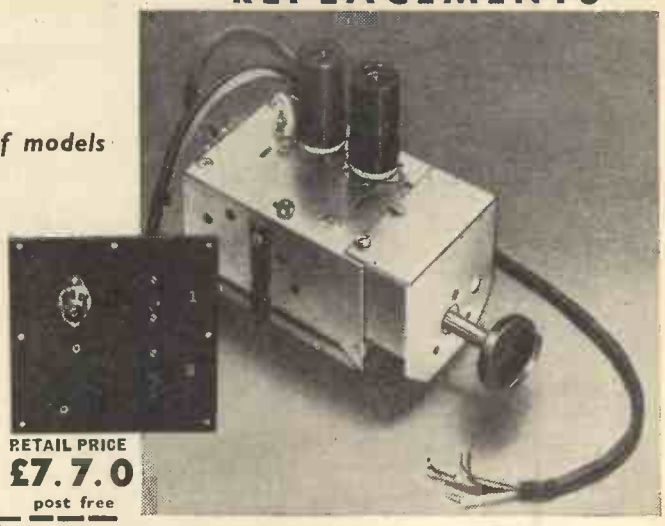

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16P	19.5	16.0	Parallel
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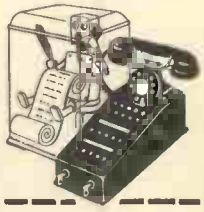

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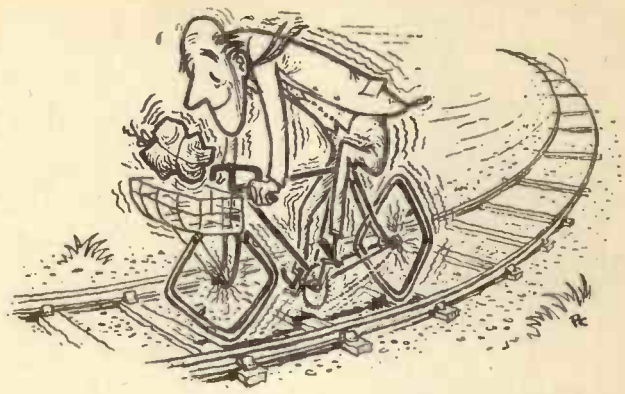

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where it is required for vibration and fatigue testing of structures, components, engineering products, engines, special metals, etc.

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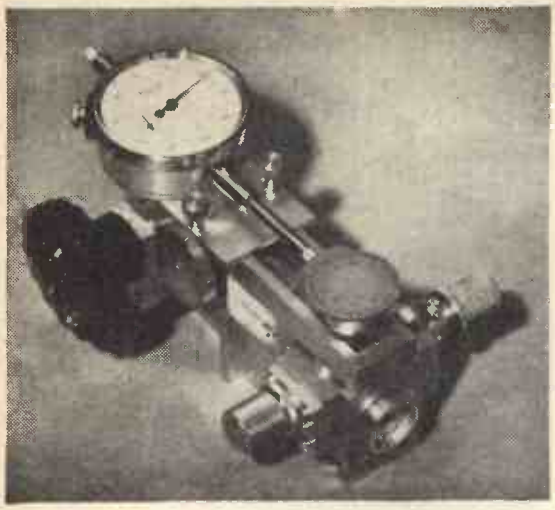

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for the 8-10 mm band

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ADAPTATAPE

is the name of the new **SONOMAG** Pre-Amplifier recommended on page 238 of the November "*Hi-Fi News*" to those already owning Hi-fi equipment and wishing to add tape reproduction of the same quality.

This is the **ONLY** pre-amp. at present available designed specially for the new Collaro Transcriptor, and rigidly fixed as a unit to it.

Demonstrations to all hi-fi enthusiasts of our pre-amp. used in conjunction with the Collaro Transcriptor Tape Unit, Collaro Transcription Motor, Leak Dynamic Pick-up and Diamond stylus, Leak Trough-line F.M. Tuner, Wharfedale Baffle 3-speaker system and Leak main amplifiers, will convince you of the fine standard of recording possible. Day, or evening (by appointment).

Price 32 gns.

(Power pack, if required, 4 gns. extra.)
Fitted into Fireside Console cabinet, oak, walnut or mahogany finish, 40 gns.

Your own Collaro Unit fitted, aligned, tested and guaranteed (at our factory only) for 16 gns.

Complete Tape Recorders, including Collaro Microphone and 1,200ft. tape. Portable 48 gns. Console (with extra large speaker) 58 gns.

Leaflet on request.

Credit facilities from:

H. C. Harridge, 8, Moor Street, Cambridge Circus, W.1.
Holleys Radio, 315, Camberwell Road, Camberwell Green, S.E.5.
Jackson Radio, 163, Edgware Road, W.2.
London Radio Supply Co. Ltd., Balcombe, Sussex.
Readings Music Stores, 11, Station Approach, Clapham Junction, S.W.11.
Sound-Tape-Vision, 71, Praed Street, Paddington, W.2.
Woods Radio, 198, Lavender Hill, Clapham Junction, S.W.11.

SONOMAG Ltd.,

2 St. Michael's Road, Stockwell, S.W.9

(Minute from Stockwell Tube) *Telephone : BRI 5441*

Best Buy at Britain's

TEST METERS
American multirange, in handsome polished wooden case with leather carrying handle. Size 6in. x 6½in. x 3¾in. 400 microamp basic movement. A.C. and D.C. volts 0-2.5, 10, 50, 250, 1,000, and 5,000. (1,000 ohms per volt.) D.C. current 0-1, 10, 100 m/Amps., and 1 Amp. Ohms 0-500, 100 K., and 1 Meg. Decibels —10 to +69. Complete with test prods, leads, circuit, instructions, and battery. New condition, tested. **£5/19/6.**

INSULATION TESTERS by Record Electric. 0-50 MegOhms. Test voltage 500. In perfect working order. Complete in leather carrying case. **£9/19/6.**

OUTPUT POWER METERS. Ex-W.D., No. 3, Mk. 2 (Windsor 150 A.). Impedance ranges 2.5 to 20,000 Ohms in 40 steps. Power ranges 0-5, 50, 500, milliWatts, and 0-5 Watts. Also scaled in dB. 3½in. M/C. meter. In oak case, 10½in. x 8in. x 5½in. In good condition. Tested. **£15.**

AVO TEST BRIDGES. Capacity 5 pFd. to 50 mFd, Resistance 5 Ohms to 50 MegOhms. Inductance can be measured against external standard. Balance is indicated on a meter, which can also be used a valve voltmeter. from .1 to 15 volts. Has leakage test and Power Factor control. For A.C. mains operation 220-240 v. Good condition. Tested. **£8/19/6.**

AVO VALVE TESTERS in Good Condition, with panel. For CALLERS only.

MARCONI SIGNAL GENERATORS
TF390G. 4-32 and 50-100 Mc/s.... **£25 0 0**
TF390G. 16-150 Mc/s..... **£27 10 0**
TF517F. 18-58 and 130-260 Mc/s. **£35 0 0**
All complete with Instruction Book, spares, Calibration Charts, etc. In original transit cases. Brand new. We have large stocks of similar quality Laboratory type equipment available to callers at very reasonable prices.

VIBRATOR PACKS. Input 6 v. D.C. Output approx. 100 v. at 30 m/Amps. D.C., fully smoothed and RF filtered. Size 6½in. x 5in. x 2in. Fitted with Mallory 629C Vibrator. Brand new, boxed, **12/6.**

HEAVY DUTY BLOWERS. For A.C./D.C. mains 200-250 v. 300 watts. 1½in. diam. outlet. Suitable for industrial use, forges, etc. With spare filter pads and brushes. Brand new. **£4/19/6.**

HEAVY DUTY LT TRANSFORMERS. 230 v. A.C. mains input. Secs. 5-0-5 v., 5-0 5 v., and 5-0-5 v., all at 5 amps., each winding. 5, 10, 15, 20, 25, or 30 v. at 5 amps., or other possible combinations. 4¾in. x 4¼in. x 6in. high. Wt. 12lb. BRAND NEW, **29/6.** ANOTHER, 230 v. A.C. mains input, two separate secondary windings, each 14 v. C.T. 12 amps. 7, 14, 21, or 28 v. at 12 amps., or other possible combinations. Wt. 24lb. Ex Admiralty. Brand new, **42/6.**
U.S.A. potted type, input 210/220/230 v., 5 secondaries, 7.5 v. 4 a., 7.5 v. 4 a., 7.5 v. 8 a. and 2.5 v. 5 a., ALL centre tapped, and 6.3 v. 4 a. These can be connected to give many useful voltages up to 31 v. 4 a. Size 6in. x 5in. x 4in. Wt. 14½lb., price **35/–.**
G.E.C. 200-250 v. A.C. mains input. 30 v. (tapped at 10 v.) 36 amps. output. 5½in. x 6in. x 7in. high. Wt. 24lb., **55/–.**

SELENIUM BRIDGE RECTIFIERS Funnel cooled. A.C. input 45 v. R.M.S. D.C. output 30 v. 10 amp. **47/6** each.

HEAVY DUTY SLIDER RESISTORS. 250 watts. Rated to carry 25 amp. .4 ohm resistance. For charging boards, etc. Worm drive. On metal stand 9in. x 4in. x 6in. high. BRAND NEW **7/6** each. ANOTHER, 12 amps., 1 ohm, 150 watts, **6/6.** ALSO 14 ohms, graded 1 to 4 amps., **7/6.**

FIELD TELEPHONES. Army type D, Mk. 5. Buzzer calling. Ideal for building sites, farms, workshops, etc. Complete with handset and batteries. Tested, **39/6** each.
CRYSTALS. 200 Kc/s American GEC, **10/–** each. 100 Kc/s R.C.A. bars, **19/6** each.
5FT. P.O. TYPE 19in. RACKS. "U" channel, heavy angle base, **59/6.**

TOP BAND R1155 L's!

Superior version of the R1155 with super slow-motion drive. 200 kc/s to 18.5 mc/s. in 5 ranges, covering the 100-200 metre trawler and shipping bands. Although not packed in original transit cases, these are in every way equal to BRAND NEW, and are fully guaranteed. Never before available at the low-price of ONLY **£12/19/6.** Carriage 10/6. **R1155A** equal to new and fully guaranteed. **£10/10/–.**
ALL R1155's are supplied with free booklet, re-aligned, and tested before despatch, and gladly demonstrated. Send S.A.E. for details of receivers and power packs, or 1/3 for 14-page illustrated booklet.
A.C. MAINS POWER PACKS WITH OUTPUT STAGE. Just plug in, NO modifications. Heavy duty quality job, guaranteed 6 months. Type A, **£4/10/–.** Type B, with 6½in. speaker, **£5/5/–.** Type C, in specially designed black crackle steel cabinet, with 8in. speaker de luxe, **£6/10/–.**
SAVE £££s. DEDUCT 10/– WHEN PURCHASING R1155 AND POWER PACK TOGETHER.

WIRELESS SET No. 19, Mk. 2.
Two transmitter-receivers and an Intercomm. amplifier in one case. "A" set covers 2-8 Mc/s. R/T and CW, and "B" set 240 Mc/s R/T only. Complete with dynamotor for 12 v. D.C. operation, 6 K7G, 2 6K8G, 2 6V6G, 6B8G, 807, EF50, EB34 and 500 microamp check and tuning meter. S.A.E. for full details and specification. Technical data available. Made in Canada, in first-class condition, **£5/10/–** plus 15/– Carr. and Pkg. Or less dynamotor, **£4/19/6.**

METER BARGAINS

RANGE	TYPE	SIZE		PRICE
50 Microamp.	D.C. M/C	2½in.	Flush circ., scaled 0-100	59/6
100 Microamp.	D.C. M/C	2½in.	Flush circ., scaled 0-1,500	39/6
500 Microamp.	D.C. M/C	2in.	Flush circular	17/6
500-0-500 Microamp.	D.C. M/C	2½in.	Flush circular, scaled 100-0-100 V.	25/-
1 Milliamp.	D.C. M/C	2in.	Flush square, Fe/NFe	22/6
100 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
150 Milliamp.	D.C. M/C	2in.	Flush square	7/6
200 Milliamp.	D.C. M/C	2½in.	Flush circular	10/6
1 Amp.	Thermo-couple	2½in.	Projecting circular	6/9
4 Amp.	Thermo-couple	2in.	Flush square	6/9
20 Amp.	D.C. M/C	2in.	Projecting circular	7/6
30-0-30 Amp.	D.C. M/I	2in.	Proj. circ., car type	5/-
15 Volts	A.C. M/I	2½in.	Flush circular	8/6
300 Volts	D.C. M/C	2in.	Flush square	10/6

METER RECTIFIERS. Full wave bridge. Brand new. Salford 1/m A. 6/6. 5 m/A., 6/6. STC 2 m/A., 5/6.

RUNNING TIME METERS. For life testing and process timing any A.C. mains apparatus. 200-250 v. 50 c/s. Indicates 1/10 to 10,000 hours on 5 scales. 4½in. diam. Good condition, tested, **35/–.**

RCA AMPLIFIERS

MODEL MI-11220. Employs 2 6L6G, 4 6J7, and 1 5U4G. Output 12 watts at 5-7.5-15-600 ohms. For 190/250 v. A.C. mains. In grey crackle case, 17 x 11 x 9in. Wt. 38lb. Brand new and boxed. Price, less valves, **£9/19/6.** Circuit supplied. OR, ready converted for use with pick-up or microphone, with tone control, **£2** extra. Set of new boxed valves, **59/6.**

CALLERS CORNER

VCR97's from ..	2/6
Indicator chassis	5/-
10 mfd. paper	2/6
8 mfd. paper	3/-
8 mfd. 500 v. Elec.	1/3
EF50's, from ..	2/6
EA50's, NEW ..	6d
EB34's, NEW ..	6d
12H6's, NEW ..	6d
Eddystone 358 Rx's 79/6	
Meters, from	6d

WIRELESS SETS NO. 17 Mk. 2. A portable 2-valve transceiver for R/T communication, freq. 44-61 Mc/s. Easily converted to the new 70 Mc/s band! Complete with valves, HR headphones and microphone. Requires 120 v. H.T. and 2 v. accumulator. Brand new Ex-Govt. surplus, tested. With circuit diagram and operating data. In wooden cabinet, with carrying handle. 15½in. x 14in. x 9in. Wt. 35lb. **59/6.**

MEDIUM WAVE COMMAND RECEIVERS. 550-1,500 Kc/s. Ideal for car radio. These have not been on the market for years! Few available. First class condition. ONLY **79/6.** Still available, BC453 (Q5'er), **59/6,** and BCXXX (Top band) 1.5-3 Mc/s. NEW, BOXED, **75/–.** FREE CIRCUIT WITH EACH RECEIVER.
TRANSMITTERS. Complete with 1626, 1629 and 2 1625's and crystal. BC457 4-5.3 Mc/s., **22/6.** NEW ditto, **29/6.** BCZZZ 2.1-3 Mc/s., unboxed, **29/6.**

PYE 45 Mc/s IF STRIPS. Complete with 7 valves and CIRCUIT. New. ONLY **39/6.**
MINIATURE 9.72 Mc/s IF STRIPS. Only 10¾ x 2¼ x 3in. Ideal for FM conversion. 2 EF92's and 1 EF91 IF Amps., EB91 Det/AVC, EF91 AVC Amp., and EF91 noise limiter. Brand new, with circuit, **45/–,** or less valves **7/6.**

RF UNITS. ALL BRAND NEW AND BOXED. RF24 **10/–,** RF25 **12/6,** RF26 **25/–.** Post 2/6.

RT37/PPN2 BEACON TRANSMITTER-RECEIVER. 214-234 Mc/s. Size 13in. x 10in. x 5in. Contains 5 3A5, 3 1S5, 1 1R5 and 2 2 v. synchronous vibrators. Operates from 2 v. accumulator via 2 built-in vibrapacks. Complete with telescopic mast antenna system (9¼ft.), lightweight headphones. Technical Manual, super quality carrying haversack, cords, co-ax. cables, plugs, etc. Total wt. 28lb. BRAND NEW, boxed, American equipment, **72/6.**

TWO-WAY MORSE TRAINING SETS, W/T Mk. 3. Consists of 2 valve oscillators (ARP12's) (one with pitch control), for 1 or 2 operators. Has provision for creating "atmospherics." In polished oak case 12½in. x 10in. x 8in., wt. 16lb. Complete with valves, leads, 2 keys, 7-way terminal board, circuit and instructions, but less batteries and phones. Ideal for Cadets, Scouts, etc. SNIP, **19/6,** Carr. **7/6.**

COMMUNICATIONS RECEIVER CR100. Covers 60 Kc/s to 30 Mc/s in 6 ranges. 2 RF's and 3 IF's, variable selectivity, B.F. Osc., etc. Operates from 210-250 v. A.C. mains. Size 16in. x 12½in. x 16½in. deep, wt. 82lb. S.A.E. for illustrated details. Overhauled, first class condition, **£21.** CR100/2 with side-tone facility, superb condition, **£25.** Plus **£2** carr. and pkg. (£1 refund when pkg. case returned.)

INDICATING UNIT 277. Contains 1in. C.R. Tube type VCR522 (same as used in G.E.C. "Miniscope"), 4 EF50, 2 EA50, and a host of useful components. Has "Focus" and "Brightness" controls, etc. Size 5½in. x 7in. x 12in. deep. All Tubes tested. **39/6.**

INDICATOR UNIT 62A. Has VCR97 with Mu-metal screen, 12 EF50, 3 EA50, 2 EB34, 4 SP61, Muirhead SM Drive, and a host of pots, switches, etc. On double-deck chassis. Ideal for 'scope. In wooden transit case. Brand new condition. **59/6.**

METAL RECTIFIERS. 250 volt, 100 m/A **6/9.** 230 volt, 60 m/A **5/-.** Many other types.

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TRADE ENQUIRIES INVITED

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WE PURCHASE ALL TYPES OF RECEIVERS AND TEST GEAR

50 MICROAMP METERS

A 2½in. flush mounting meter housed in a grey instrument case, complete with a chrome handle. Resistance 800 ohms. Supplied brand new and tested, 59/6 each.

MODULATION TRANSFORMERS. Collins type, potted. Push-pull 807 to parallel 807, 20 watts audio. Brand new 12/6 each.

HEADPHONE ADAPTORS. High to low impedance matching, brand new, 1/3.

COPPER AERIAL WIRE. Ex-U.S.A. 300ft. reel, 3/6.

WESTON DUAL RANGE OHMMETERS

American test instruments by two famous manufacturers. Incorporates a 2½in. moving coil meter, ranges 0-2,000 and 0-200,000 ohms. Price 39/6 each, brand new with leads and leather carrying case.

1.5 VOLT DRY CELLS. Type 5. Large tubular size, extra long life. Brand new and sealed, 1/3 each.

EX. A.M. SWITCHBOXES. Contains three separate 5 amp. on/off switches moulded in one Bakelite block. Brand new 1/9 each.

ROTARY CONVERTORS. Input 24 volt D.C. Output 50 volt A.C. 50 watts. Brand new, 29/6 each.

6 VOLT VIBRATOR PACKS

6 volt D.C. input. Outout 120 volts 60 m/a. Fully smoothed, uses standard Mallory 4-pin vibrator. Compact in size. Supplied brand new and boxed, 15/- each.

WAFER SWITCHES. Small. 2 p. 2 w. 1/6. 3 p. 4 w. 2/6. 4 p. 3 w. 2/6. 2 p. 6 w. 2/6. 1 p. 12 w. 2/6. Meter switch 2 p. 11 w. 2 band, 2/6. Ceramic 4 p. 4 w. 2 bank, 3/6. Large Tx. ceramic, 2 p. 6 w. 2 bank, 7/6.

SOUND POWERED EARPIECES. Can be used as a two way communication, no batteries required. Brand new 3/6 each. Brand new sound-powered telephone handsets, 19/6 each.

VIBRATOR POWER UNIT 173. 24 volt D.C. input. Output 120 volt 60 m/a., fully smoothed. Uses 12 volt 4-pin vibrator and contains transformer, choke, condensers, and 2 mains 60 m/a. metal rectifiers. Unused, price 11/6 each.

A.R.88 WAVECHANGE SWITCHES

Ceramic, 8 bank, 6 position, complete with screens. BRAND NEW and boxed, 17/6 each.

CRYSTAL MICROPHONE INSERTS. Extra sensitive, ideal for amplifiers etc., 4/6 each.

HEAVY-DUTY SLIDER. 1 ohm, 12 amps. Brand new 6/6 each.

ADMIRALTY REFLEX RE-ENTRANT P.A. LOUDSPEAKERS

Twin units. Impedance 15 ohms. Extremely sensitive and directional. Ideal for all outdoor P.A. work. Price 32/6 each.

TRANSMITTER/RECEIVER No. 19 Mk. II

Equipment comprises 3 separate units built into one chassis and separate power pack.
Specification: "A" set. Transmitter/receiver. Frequency coverage 2-4.5 mc/s. and 4.5-8 mc/s. For R.T., C.W. or M.C.W. Range on R.T. 15 miles, C.W. 50 miles. Superhet receiver, 465 kc/s. I.F., B.F.O., etc. Rx. Valve line-up: 6K7, RF., 6K8 mixer, 2 6K7 I.F., 6B8 det. A.F. phone output. Tx.: 6K8 mixer, BFO, EF50 buffer, EB34 ADC, 807 P.A. "B" set. Transmitter/receiver 229/241 mc/s. Local use up to 1 mile. Valve line-up: CV6, 2 6K7 and 6V6. Inter Com. set. 2 valve A.F. amplifier for vehicle crew intercommunication. Valve line-up: 6K7 and 6V6.
A 2½in. meter is built in reading L.T. and H.T. voltages, drive, etc. POWER UNIT. 12 volt D.C. input. Output 275 volts 110 m/a., and 500 volts 50 m/a.
Equipment is of American manufacture and is supplied in good condition. Price, complete with power pack only £5/10/- each, plus 15/- carriage. Less power pack £4/19/6.

BENDIX COMMAND RECEIVERS

Brand new and boxed, complete with all valves and circuit. Top band model, 1.5 to 3 mc/s. 75/- each.

BENDIX COMMAND TRANSMITTERS. Complete with all valves and crystal. Coverage 2.1 to 3 mc/s. 29/6 each. Coverage 4-5.3 mc/s, brand new, 29/6.

R.1155 COMMUNICATION RECEIVERS, MODEL L

Latest issue by the Ministry. Similar to the model N, incorporating the trawler band. Frequency coverage, 200-500 kc/s., 600-1,500 kc/s., 1.5-3 mc/s., 3-7.5 mc/s., 7.5-18.5 mc/s. Supplied as new, aerial tested and complete with illustrated descriptive leaflet. Price £12/19/6 each. A combined A.C. mains power pack and output stage can be supplied for the above receiver at an additional cost of 85/- each.

MARCONI U.H.F. SIGNAL GENERATOR T.F. 517, MODULATION GENERATOR T.F. 675

Complete station comprising TF 517 signal generator, frequency coverage 16-58 mc/s. and 150-300 mc/s. and TF.675 pulse modulator, repetition speed 50-3,000 cycles, pulse width 2-12.4 μ sec. Supplied brand new in original transit case with instruction book and full complement of leads. £42/10/- each.

POWER UNIT TYPE 3

A complete A.C. mains power pack, input 200/250 volts. Output 250 volts D.C. 100 m/a. and 6.3 volts 4 amps. Fitted with H.T. voltmeter and current meter. Fully smoothed, choke and paper condensers. Housed in grey case for 19in. rack mounting. Supplied in brand new condition, 72/6 each.

FIELD TELEPHONES

Type Don Mk. 5. Buzzer calling. Ideal for inter office or house communication. Supplied complete with two 1.5 volt cells, tested and ready to operate. Price only 39/6 each.

BARGAIN MAINS TRANSFORMERS

All new and unused.

L.T. TYPES

1. Pri. 220/240 v. Sec. 6.3 v. 1.5 a., 5/9.
2. Pri. 200/250 v. Sec. 6.3 v. 3 a., 8 v. 1.5 a., 9/6.
3. Pri. 200/250 v. Sec. 3, 4, 5, 6, 8, 10, 12, 15, 18, 20, 24 or 30 v. 2 a., 18/6.
4. Pri. 200/250 v. Sec. 3, 6, 9, 12 24 or 36 v. 5 a., 35/-.
5. Pri. 200/250 v. Sec. 4 v. 14 a., 6.3 v. 1.5 a. ct., 10/6.

INSTRUMENT TYPES

1. Pri. 220/240 v. Sec. 200 v. 25 m/a., 6.3 v. 1 a., 10/6.
2. Pri. 230 v. Sec. 195 v. 85 m/a., tapped 130 v. and 65 v., 6.3 v. 5 a., 6.3 v. .3 a., 14/6.

H.T. TYPES

1. Pri. 200/250 v. Sec. 250/0/250 v. 60 m/a. 6.3 v. 3 a., 5 v. 2 a., 18/6.
2. Pri. 200/250 v. Sec. 250/0/250 v. 80 m/a. 6.3 v. 4 a., 5 v. 2 a., 18/6.
3. Pri. 200/250 v. Sec. 350/0/350 v. 80 m/a., 6.3 v. 4 a., 5 v. 2 a., 18/6.
4. Pri. 110/230 v. Sec. 250/0/250 v. 175 m/a., 6.3 v. 5 a., 5 v. 3 a., 35/6.
5. Pri. 200/250 v. Sec. 300/0/300 v. 150 m/a. 6.3 v. 5 a., 5 v. 3 a., 32/6.

AUTO TRANSFORMER

110/120/200/210/220/230/240/250 v. 150 watts, 21/-.

CHARGING TYPES.

1. Pri. 200/250 v. Sec. 9 or 15 v. 1 a., 9/9.
2. Pri. 200/250 v. Sec. 3.5, 9 or 17 v., 2 amp., 14/3.
3. Pri. 200/250 v. Sec. 3.5, 9 or 17 v., 4 amp., 16/6.

SELENIUM CHARGING RECTIFIERS.

Full wave and bridged.
12 v. 1 a., 6/3; 12 v. 2 a., 9/3; 12 v. 4 a., 13/9; 12 v. 10 a., 32/6; 24 v. 8 a., 49/6.

ALUMINIUM CHASSIS.

Best quality, 18 swg. Four sided, reinforced corners.

6 x 4 x 2½in.	3/6
7½ x 5½ x 2½in.	4/6
10½ x 7½ x 2½in.	5/3
11½ x 7½ x 2½in.	6/-
13½ x 7½ x 2½in.	6/9

NOTE OUR PRICES.

PANORAMIC ADAPTORS

Brand new and boxed Ex-U.S.A. For use with receivers having an I.F. of 455/475 kc/s., giving a bandwidth of 200kc/s. 110/230 volt A.C. operation. Price £30 each.

INSTRUMENT POTENTIOMETERS.

Brand new and boxed. Rating 100,000 ohms, 10 watts, 3½in. dia. Ideal for bridges, etc., 10/6 each. Ditto, twin gang, 5 k. ohms, 10/6.

ROTARY CONVERTORS

Input 24 volts D.C. Output 230 volts 50 cycles A.C. 100 watts. Brand new 92/6 each.

G.P.O. BELL UNITS No. 1.

Supplied brand new in wooden box, complete with two bells, induction coil and condenser, 7/6 each.

HOURS OF BUSINESS: 9 a.m.-6 p.m. Thursday 1 p.m. Open all day Saturday. Please print name and address clearly. Also include postage on all items.

AMERICAN MULTI-RANGE TESTMETERS

1,000 ohms per volt, 400 microamp basic movement. Ranges as follows: A.C. and D.C. volts, 0 to 5,000 volts in 6 switched ranges. D.C. current, 1ma., 10ma., 100ma. and 1 amp. Resistance measurement from .1 ohm to 1 megohm. Decibels from —10 db to +15 db.
The instrument is housed in a polished wood case, complete with leather carrying handle, test prods and battery. Guaranteed perfect order and tested before despatch. Price **£5/19/6** each.

MAINS NEON PANEL INDICATORS. Chrome escutcheon. 200/250v. Red, amber or clear, 3/9 each.

460 kc/s B.F.O. UNITS. Brand new and complete with 1S5 valve, fully screened in aluminium case, only 8/6 each.

EDDYSTONE POWER UNITS. 200/250 volts input. Output 175 volts 65ma., and 6.3 volts 3 amps. Fully smoothed, 5Z4 rectifier, 32/6 each.

SMOOTHING CHOKES

ALL NEW AND UNUSED

G.B. 20h. 175ma., 10/6; Parmeko 8H. 250ma., 10/6; Parmeko 9h. 100ma., 7/6; Parmeko 8h. 50ma., 5/6; Parmeko C core, 4h. 22.5ma., 4/6; Collins 8H. 100ma., 8/6; Parmeko swinging choke, 3.6–4.2H. 250ma. 20H. no D.C., 10/6; 15H. 60ma., 5/6; STC 10H. 60ma., 4/6.

MARCONI CRYSTAL CALIBRATOR
Frequency coverage 170/240 mc/s. Directly calibrated, accuracy .001%. Operation 200/250 volts A.C. Supplied complete with 5 mc/s crystal and spare set of 5 valves, in original transit case, brand new with instructions. **£4/19/6** each.

SURPLUS SPEAKER BARGAINS
All new and unused

Elac 5in. 3 ohm, 17/6; Elac 6½in. 3 ohm, 17/6; Elac 8in. 3 ohm, 19/6; Elac 10in. 3 ohm, 27/6; Elac 7X4 elliptical 3 ohm, 18/6; Plessey 2½in. 3 ohm, 16/6; Plessey 10X7 elliptical 3 ohm, 27/6; Goodmans 3½in. 3 ohm, 17/6; Std. pentode o/p transformer, 4/6.

A.C. MAINS BLOWER MOTORS

220/230 volt 300 watts. 1½in. diameter outlet. Housed in metal box and fitted with dust filter pads. Supplied complete with 4 spare filters, 2 way outlet adaptor and 2 lengths of hose. Brand new only **£4/19/6** each.

GERMANIUM CRYSTAL DIODES. ONLY 10d. R.E.P. dual range crystal coil with circuit, 2/6. .0005mfd. air spaced tuner, 3/6. 2,000 ohm headphones, 12/6 pr.

ELECTROLYTIC CONDENSERS. All new stock

8mfd. 150v. 1/-; 8mfd. 450v. 1/9; 8X8mfd. 450v. 3/6; 8X16mfd. 450v. 3/6; 8X16mfd. 500v. 4/3; 16mfd. 450v. 2/9; 16mfd. 500v. 3/3; 16X16mfd. 450v. 3/6; 16X16mfd. 500v. 4/3; 30mfd. 450v. 3/3; 32X32mfd. 350v. 4/3; 32X32mfd. 450v. 4/6; 64X120mfd. 275v. 3/6; 100X200mfd. 350v. 7/6; 40mfd. 450v. 3/9; 50X50mfd. 275v. 3/9; 25mfd. 25v. 1/9; 50mfd. 50v. 1/9; 100mfd. 25v. 1/3; 250X250 mfd. 6v. 2/6; 500mfd. 12v. 1/3; 6,000mfd. 6v. 3/6; 1000+2000mfd., 6v. 3/6; Ceramic/mica 1pf–.005mfd. 6d. Paper .01mfd.–.1mfd. 9d.; 25 1/-: .5 1/3.

GRAM MOTORS

Special offer. Garrard 200/250 volt A.C. gram motors with turntables. Speed adjustable from zero to 45 rpm. A real bargain at only 22/6 each.

AVO VALVE TESTERS

A superb offer of these fine test instruments which are supplied in new condition in original cases. Equipment is in 2 parts. One is the valve panel with selector switches and the other the meter with voltage adjustment controls, etc., and incorporates an automatic cut-out. Existing bases on valve panel are: B3, UX4, B7g, UX7, 1/octal, Mazda octal, B5, UX6, B7, loctal, UX5, B9G. 3 blanks are provided to fit latest type bases, i.e. B9A and B8A. Extremely simple to operate. Only **£5/19/6** each.

EX-NAVY SOUND POWERED TELEPHONES

This type requires no batteries to operate. Fitted with hand generator for calling giving a high pitch note. Can be fitted anywhere. Ideal for factories, offices, field activities, etc. Only 45/- each.

MODULATOR 67

These bargain Instruments contain a COMPLETE A.C. MAINS POWER PACK, input 230 volts 50 cycles. Output 350 volts. 120ma. and 6.3 volts 5 amps. Choke and condenser smoothed and uses 5Z4 rectifier. (Transformer actually 200 ma.) Also included in the unit are 11 other valves, 5 SP61, 1 VR116, 2 EB34 and 3 EA50, and many other useful components, pots, resistors, switches, etc. Size of case 18 x 9 x 7in., which is finished in grey. Supplied brand new, 49/6 each.

EXPLODERS-CONDENSER-DYNAMO MK1

This unit was designed for detonating an explosive charge but can be used alternatively as a portable photo flash generator, the advantage being that no batteries are required. Operation is by hand generator supplying A.C. pulses, stepped up through a transformer, rectified by 2 J 50 recs and a final charge is developed across a 6mfd. paper condenser of 1,800 volts. A neon indicates when charged, press button to fire. Supplied brand new with circuit, £3/19/6 each.

AMERICAN GEARED MOTORS

American 24 volt D.C. motors with built-in precision gearbox giving twin outputs 20 r.p.m. and 6 r.p.m. Will also operate on 12v. giving reduced outputs. Size 7in. x 1¾in. Shaft dia. ¼in. Supplied brand new only 29/6 each.

AMERICAN BEACON TRANSMITTER/RECEIVERS

RT 37/PPN-2. Brand new and boxed, complete with instruction book. Equipment comprises transmitter/receiver with 9 valves (5 3A5, 3 1S5 and 1 1R5), with built-in 2v. vibrator power pack, spare vibrator, headset, connector leads and 10ft. collapsible aerial. Frequency coverage 214/238 mc/s. Price 72/6 each.

AMERICAN ROTARY GENERATORS

Input 12 volt D.C. Output 250 volts 80ma. Fitted with blower attachment which can be easily removed if desired. Brand new **22/6** each. Ditto with 6 volt input 22/6 each.

MARCONI SIGNAL GENERATORS

Model TF390G. Frequency coverage 16-150 mc/s. 200/250 volt A.C. operation. Supplied brand new in original transit case, complete with calibration charts, **£25** each. Also TF-144 85kc/s-25 mc/s. Supplied fully overhauled, guaranteed, **£75**. Marconi Valve Voltmeters TF-428B. Brand new, **£25**. Marconi "Q" meters, fully overhauled, guaranteed, **£75**

P/O RELAYS AND KEY SWITCHES Extensive stocks available at "CHEAP" prices. All enquiries welcomed. Special American relay offer. Typel. 3,500 ohm coil, 1 pr. changeover contacts, 12v. 6ma., 5/6. Ditto 6,500 ohms, 2ma., 6/6 each.

DEAF AID EARPIECES. Brand new, 30 ohm resistance, 3/6. Leads 1/-. Midget valve CK505, 2/6. 1 meg. pots w/switch, 1/-. Switch 1 pole 4 way, 1/-. Output transformer, 2/6.

AMERICAN MULTI-RANGE TESTMETERS

Precision series, fitted with the larger 4½" meter. 1,000 ohms per volt. Ranges as follows: A.C. and D.C. volts 0-6,000 volts. D.C. current 0-12 amps. Resistance 0-10 megohm. Six output ranges and six DB ranges —12 to +78 DB. Supplied brand new in wooden carrying case complete with leads and instructions, **£8/19/6** each.

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0/100 μamp. 2½in. F.M.M.C.	39/6
0/1 m/amp. 2½in. F.M.M.C.	25/-
0/1.5 amp. A.C./D C. 2in F.M.M.I.	6/6
50 M/amps. 2in. F.M.M.C.	7/6
150 M/amps. 2in. F.M.M.C.	6/9
200 M/amps. 2½in. F.M.M.C.	9/6
1 amp. R.F. 2½in. Pj. T.C.	5/-
4 amp. R.F. 2in. F.M.T.C.	5/-
300 volt D.C. 2in. F.M.M.C.	10/6
300 volt A.C. 2½in. F.M.M.I.	25/-
500/0/500 microamp. 2½in. F.M.M.C.	25/-
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ALL NEW AND UNUSED

2m/a meter rectifiers, S.T.C.	5/6

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Large stocks held. Few examples:
5V4 8/6, 6AG5 3/6, DK96 9/6, EY51 10/6, EF86 12/6, 5Y3 7/3, 6V6 6/6, DL96 9/6, EF80 10/6, EL84 12/6, 5U4 8/6, 6X5 7/6, DF96 9/6, ECF80 12/6, EZ81 10/6, 6H6 1/9, 6SN7 6/6, DAF96 9/6, ECF82 12/6, ECC83 10/6, 6/6 3/6, KT66 12/6, DF91 7/6, ECC84 12/6, ECL80 11/6, 2D21 10/6, VU111 1/9, EF39 5/6, ECH42 10/6, ECH81 10/6.
ALL NEW AND GUARANTEED

B.S.R. 4-SPEED RECORD CHANGERS.

Latest model, turnover head, £8/15/- each.

COSSOR DOUBLE BEAM OSCILLOSCOPES

Model 339A. 200/250 volt A.C. operation. Supplied in perfect working order **£27/10/0** ea.

WESTON MODEL 785

MULTI-RANGE TESTMETER

Sensitivity 20,000 ohms per volt D.C. 1,000 ohms per volt A.C. Resistance ranges up to 30 megohm. D.C. current ranges, 1ma., 10ma., 100ma., 1 amp and 10 amp. A.C. current 500ma., 1 amp. 5 amp. 10 amp. D.C. volts. 1, 10, 50, 200, 500, 1,000, 2,000v. A.C. volts. 5, 15, 30, 150, 300, 750, 1,500v. Supplied in wood carrying case complete with test leads and batteries in perfect working order. **£12/10/-** each.

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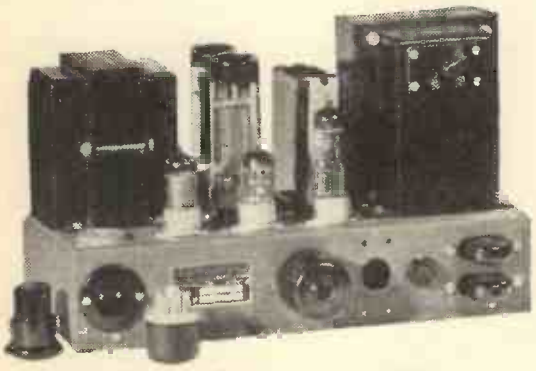
Exclusive Lowther Design and Build



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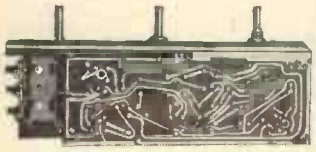
LASKY'S RADIO

LASKY'S BATTERY PORTABLE FOR HOME CONSTRUCTION ON PRINTED CIRCUIT



PEAK VALUE FOR MONEY has been obtained without any sacrifice of quality or design and the use of the printed circuit completely eliminates wiring errors.

10 STAR FEATURES

- ★ PRINTED CIRCUIT, size 7¼in. × 2¼in.
- ★ 4-valve Superhet, med. and long waves.
- ★ Low consumption Valves. Double Battery Life.
- ★ Ferrite Rod Internal Aerial.
- ★ 3 or 5in. P.M. Moving Coil Speaker (your choice).
- ★ Brand New T.C.C. Capacitors.
- ★ Automatic Volume Control.
- ★ New Style Contemporary Case.
- ★ Lightweight and Handsome Appearance.
- ★ Every Component available separately.

CAN BE BUILT FOR

£7.7.0

COMPLETE WITH VALVES

Postage 3/6 extra

CIRCUIT DIAGRAM with assembly data, all instructions, illustrations and full shopping list. Price 1/6 post free.

DEMONSTRATION MODELS AT BOTH OUR ADDRESSES

POWER SUPPLY UNIT for the above and suitable for most other battery portables. COMPLETE KIT. containing printed circuit. 45/–, post 2/–. For 200–250 A.C. mains. Full details on request.

HI-FI SPEAKERS

Large stocks Goodmans, Wharfedale, G.E.C., Lorenz, etc., including the new Wharfedale 3-speaker system.

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Full range in stock. Quad, Rogers, Leak, R.C.A., Pamphonic, Unitelex, W.B., etc. Demonstrations at Tottenham Court Road.

IGRANIC JACK PLUGS, 2/6.

BUILD YOURSELF A HIGH GRADE RECORD PLAYER!

We can supply the Units, Amplifiers and Cases for building either the Auto-Changer or Single Player illustrated

Take this opportunity to build yourself an Auto or Single Player of high performance and handsome appearance. Any of these Units demonstrated at either of our addresses.

AMPLIFIER. 4 watt, 3 valve (EL84 output, L63 and EZ80 rect.), 7in. × 4in. elliptical speaker, separate bass and treble controls. Will suit any type of auto-changer or single player. Price, complete with 3 valves, knobs and speaker. Post 5/– **£5/9/6.**

CASE FOR AUTO-CHANGER, as illustrated, size 18in. × 15in. × 9in., fawn/brown finish, **79/6** Post 5/–. (Others from 69/6.)

CASE FOR SINGLE PLAYER, as illustrated, size 15½in. × 13in. × 7½in., grey, with black/silver bands. **69/6** Post 5/–.

(Others from 49/6.)

PLAYER UNITS, We recommend the following new Collaro units with Studio turnover crystal pick-up:—

4-speed AUTO-CHANGER, RC4/456	£13 13 7
3-speed AUTO-CHANGER, RC54	£8 19 6
4-speed SINGLE PLAYER, 4/456	£9 7 0

(Other types of Auto-Changers and Single Players in stock.)
All the above are available separately.

CONTINENTAL AM/FM RADIOGRAM CHASSIS

LASKY'S PRICE
£16.19.6
Carr. 10/6.

Very special offer of a limited number only at wonderful bargain price! Built throughout of latest high grade components. 5 valve plus metal rect., gram socket and switch, piano key wavechange, tone control, independent AM/FM tuning. Covers med., long and V.H.F. wavebands. Valve line-up: ECC85, ECH81, EF89, EABC80, EL81. For A.C. mains 100-250 v.

WHATEVER YOU NEED TRY LASKY'S FIRST
★ *We have one of the largest and most comprehensive stocks in London and are always at your service with advice and assistance with your problems.*

LARGE SELECTION OF 3- and 4-SPEED AUTO-CHANGERS. B.S.R., Garrard, Collaro, etc. Our stocks are constantly changing. See us for what you want.

GARRARD RC.80. 3-speed Auto-Changer. Full length arm with two XMS heads or GC2 t.o. crystal head. Brand new, in makers' cartons. List £20/15/–.
LASKY'S PRICE **£13.19.6**
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B.S.R. 4 Spd. with t.o. crystal pick-up. Incorporates auto and manual control enabling records to be played singly. Brand new, in makers' cartons.
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B.S.R. type TU.8, as illustrated. 3-spd. motor and pick-up with HGP.59 t.o. crystal complete with styli.
LASKY'S PRICE **92/6**
Post 3/6.
Above motor and turntable less pick-up, 57/6. Post 2/6.

PICK-UP BARGAINS

Long playing and standard, complete with turnover crystal cartridge and styli.
DECCA HI/G, brown plastic **32/6**
B.S.R. HGP59/3, cream finish. **37/6**
Post 2/6.

T.O. CRYSTAL CARTRIDGES
B.S.R. complete with two styli.
LASKY'S PRICE **18/6**
Post free.

ACOS type HGP.37, as used in latest radiograms. L.P. and standard. Complete with styli. **22/-**
Post 1/–.

TRANSCRIPTION TURNTABLES by Lenco, Garrard, Collaro.

MORE MONEY-SAVING LASKY BARGAINS ON NEXT PAGE

LASKY'S RADIO

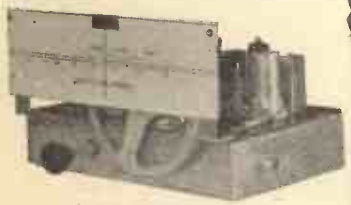
SAVE POUNDS! ORDER BY POST IF YOU CANNOT CALL

TAPE DECK CASES ALMOST HALF-PRICE

Strongly made and finished with light grey leatherette with black/silver bands, strong hinges and clasps. Pocket in lid for tapes and spools, door for microphone, etc. Overall dim.: 15¼in. long, 13¼in. wide, 9in. deep. Inside dim.: 14¾in. × 12¼in. × 5¼in. A real general purpose job; will take almost any type of Deck including Collaro Tape Transcriptor, also almost any type of Record Changer including RC.80, etc.

LASKY'S PRICE 59/6 Post 3/6.

LARGE SELECTION OF CABINETS for TV and radiograms, also carrying cases for record players, tape recorders, etc. We have a Case for any type of unit or combination of units. Your enquiries invited.



LASKY'S F.M. TUNER

FOR HOME CONSTRUCTION ON A PRINTED CIRCUIT

A really first-class Unit.

Note these star features:—

★ HIGH SENSITIVITY.
★ ALL BRAND NEW T.C.C. CONDENSERS.
★ AERIAL COIL AND R.F. COUPLING COIL PRINTED ON CIRCUIT.
★ 5 VALVES AND 2 GERMANIUM DIODES.

By the use of a printed circuit the I.F. and R.F. amplifiers are extremely stable at maximum gain and results are consistent on all tuners.

Valve line-up:—
R.F. Amplifier, Z719 or EF80.
Mixer and Osc., B719 or ECC85.
1st I.F. amp., W719 or EF85.
2nd I.F. amp., W719 or EF85.
2 Germanium Diodes GEX.34.
Driver Limiter, Z719 or EF80.

CAN BE BUILT FOR 8 GNS. (Including Valves)

Write for full instructions, data and illustrations, 2/6 post free.
All parts available separately.

WE STRONGLY RECOMMEND THE LATEST *Brenell* TAPE EQUIPMENT

DECK Mk. II, 18 gns.

AMPLIFIER Mk. II, 4 watts, for use with 3 ohms speaker. Magic Eye, 18½ gns.

CARRYING CASE, £4/18/-.

COMPLETE EQUIPMENT less mike, with tape, in carrying case, ready for use, 48 gns.

Come and inspect it and have a demonstration. Note these features.

★ Convertible to Sterophonic Recording ★ 3 independent motors ★ 3 recording speeds: 3¾, 7½ and 15 i.p.s. ★ twin track recording on 7in. reels ★ fast forward or reverse in 45 secs. ★ plays all types of pre-recorded tapes ★ Magic Eye recording level indicator ★ baffle-mounted elliptical speaker ★ 4 watts undistorted output.

Demonstrations at both addresses. Full details post free.

BIG BARGAIN IN ALL DRY POWER UNITS

By Decca. Suitable for any battery radio using 1R5, 1T4, etc., 67½ volts H.T., 1½ volts L.T. Mains input 200-250 adjustable. On metal chassis with rubber feet and black plastic cover. Size: 7in. × 5in. × 1¾in. Mains lead and on/off switch. Complete with two metal rectifiers, ready for use. Listed at £4/15/-.

LASKY'S PRICE 35/- Post 3/6.

Note: If this unit is too large to fit into your portable, remember you stand your set on or by it.

NEW W/B F.M. TUNER

Gives outstanding performance due to the specialised design incorporating advanced circuits. Wide freq. range—87.5 to 108 Mc/s. Price **£25**

Full details on request.

NEW JASON switched-tuned F.M. UNIT

A new 4-valve F.M. Tuner in which the desired programme is tuned-in by a 3-position switch. Stable, easily pre-tuned and easily installed. **£19/16/2**

Full details on request.

JASON "ARGONAUT"

A super-sensitive Tuner for F.M. and medium waves. Complete parcel with power supplies, £13/19/6. Post 3/6.
Data Book, 2/-. All components available separately.
Chassis Assembly, 57/9, post 2/6.
I.F. and Coil Set, 78/-, post 1/6.

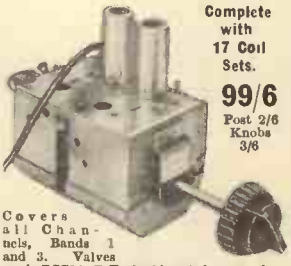
JASON F.M. TUNER

Special parcel containing data book, chassis, front panel, dial, drive tuning condenser, full sets of coils. I.F.'s ratio detector, etc. Post 2/6. **68/9**
DATA BOOK with price list 2/-.
Note: This tuner uses 4-6AM6 and 2 crystals and can be built for £6/15/-, plus 3/6 post.

DULCI F.M. TUNER

Incorporates its own power supply and provides complete F.M. coverage.
Complete **£17.10.0**
Carr. & Pkg. 7/6.
DULCI AM/FM TUNER £20/17/-.

FAMOUS MAKE TURRET TUNER



Complete with 17 Coil Sets. **99/6** Post 2/6 Knobs 3/6

Covers all Channels, Bands 1 and 3. Valves used: PCC84, B.F. double triode, cascode R.F. amplifier, PCF80, triode pentode, f.c. and mixer. I.F. output 33-38 Mc/s. Easily modified to other I.F. outputs.
Full instructions and circuit diagram supplied.

New TSL F.M. TUNER

High Stability model that will work well in extreme fringe areas. 6 valves including Magic Eye and Power supply using the latest Gorler permeability Unit. Frequency 85-101 Mc/s covering all present and future FM/VHF transmissions. A Tuner of high sensitivity and high stability. Complete £17/10/-.
Full details on request.

METER BARGAIN

2½in. moving coil. Brand new micro-ammeters F.S.D. 0-750 micro-amps., 15 ohms resistance. Post extra. **15/-**

LARGE RANGE OF TAPE DECKS

Collaro "Tape Transcriptor," £20.
Truvox.....23 gns.
Lane.....£18/10/-.
Brenell.....18 gns.
Wearite £35 and £40.

TAPE RECORDERS

Large range, Elizabethan, Truvox, Sound, Vortexion, Brenell, etc.

TAPE DECK MOTORS

Anti-clockwise, shaded pole. Collaro 25/-. Garrard 26/6. B.T.H. 29/6. Post extra.

NEW PLASTIC RECORDING TAPE

"Ferrovoice," on plastic spool, 1,200ft. List, 32/6.
LASKY'S PRICE 25/-
Post 1/-.
Spare 7in. spools, 3/6.

SPECIAL OFFER! Magnetic Recording Tape, kraft base. On Cyldon metal spools: 1,200ft. 11/6; 600ft.
On plastic spools: **7/6**
1,200ft. 12/6; 600ft. 9/6.
Post 1/-

PURETONE Tape on plastic spool, 1,200ft., 14/11.
Post 1/- extra.
All makes of Tape including thin long-playing.

TAPE SPOOLS

7in. plastic 3/6
5in. metal 1/6
3in. plastic 3/-
9in. Ferrograph 9/6
Post 9d.

GERMANIUM CRYSTAL DIODES

GEX.00 ..... 1/6
GEX.34 ..... 3/6
GEX.54 and OA71..... 5/-

FERRITE ROD AERIALS

Med. and long waves, wound, ready for use. Each 6/9, post 1/-

FERRITE ROD
5in. long, ¼in. diam., with full instructions for making a Ferrite rod aerial, 2/6, post 1/-.

STANDARD 2-GANG CONDENSERS

.0005 mfd., with fixing feet. Each 5/11. Post 1/6.

TRANSISTORS

Special Offer. Junction type suitable for use in local station receivers, amplifiers and pre-amplifiers, etc.
Each **10/-**
Post free.

MULLARD TRANSISTORS

OC70	OC71	OC72
21/-	24/-	30/-

BRIMAR TRANSISTORS
TS1, 18/-. TS2, 21/-. TS3, 24/-. TP1 or TP2, 40/-.

MORE MONEY-SAVING LASKY BARGAINS ON NEXT PAGE

EVERYTHING FOR HOME CONSTRUCTOR & SERVICEMAN

LASKY'S RADIO

AMAZING OFFER!

5-valve RADIO CHASSIS

Brand new and unused. A.C./D.C. 200/250 volts. I.F. 465 kc/s. A.V.C., 4 watts output, 3-station pre-set, frame aerial, fully aligned, chassis 10×5½in., max. height 5½in. Completely wired and ready for use, with the addition of a speaker and output transformer. Two controls, volume and station switch. Valves used: 10C1, 10F9 or UF41, 10LD11, 10P14, U404 or UY41.

LAST FEW TO CLEAR AT GREATLY REDUCED PRICE, less valves. Post 3/6. **32/6**

5-VALVE RADIOGRAM CHASSIS complete with valves, £9/19/6. Carr. & Pkg. 7/6.

MOVING COIL P.M. SPEAKERS

2½in. 3in. and 3½in., 19/6.

5in.	6½in.	8in.	10in.	12in.
16/6	17/6	25/-	32/6	29/6

6½in. with transformer .. 21/–
7×4in. Elliptical 19/6
10×6in. Elliptical 32/6

GOODMANS 12in. AUDIOM 50 P.M. SPEAKERS

10 watts. Limited number only. Listed at £6/15/-.
LASKY'S PRICE **97/6**
Post free

WHARFEDALE 3-SPEAKER SYSTEM

SFB/3. Consists of 3 low resonance speakers and special crossover unit fitted in a handsome resonance-free cabinet, size 34in. × 31in. × 12in. Freq. range 30 c/s. to 20,000 c/s
New Price, complete, **£39.10.0**
Free demonstrations at Tottenham Ct. Rd.

LORENZ 3-SPEAKER SYSTEM

A highly efficient system specially designed to give the widest angle of sound distribution and unsurpassed frequency response. Comprises one 12in. Unit and two treble Units
Complete, **£14.19.6**

HI-FI ELECTROSTATIC SPEAKERS ("TWEETERS")

Easy to fit to any radio, TV receiver or amplifier. Full data and circuit diagram supplied.
LSH75. For outputs up to 6 watts, 8/-.
LSH518. For outputs of 10-12 watts, 12/6.
LSH100. For outputs up to 20 watts, 14/-.
LPH65. Moving coil Tweeter. Imp. 5.5 ohms, freq. range 2,000-2,200, 50 c/s. For outputs up to 6 watts. 2½in. diameter, All post free. 39/6.

LASKY'S RADIO CONSTRUCTOR PARCELS

PARCEL No. 1

Contains everything to build a 4-valve 3-wave superhet for 200/250 A.C. mains. Uses 6K8, 6K7, 6Q7, 6V6 valves. Attractive wood cabinet, walnut veneer, or plastic cabinet as illustrated. Size 12×6½×5½in. deep. CAN BE BUILT FOR
Carr. and packing 2/6. **£7.19.6**

PARCEL No. 2

Contains everything to build a T.R.F. 3-valve set for 200/250 A.C.mains, medium and long wave. Uses 6K7G, 6J7, 6V6 and metal rectifiers. Neat plastic cabinet, walnut or ivory finish, or wood cabinet. Size 12×6½×5½in. deep.
CAN BE BUILT FOR **£5.10.0**
Carriage and packing 2/6.

INSTRUCTION BOOK for either above sets 1/- post free.

CABINETS ONLY, plastic or wood, 17/6. Post 2/6.

All components available separately.

ALUMINIUM CHASSIS

18 S.W.G. undrilled, 4 sides, reinforced corners. Depth 2½in.
6×4 4/-; 12×8 7/-; 16×10 8/3;
8×6 5/-; 14×9 7/6; 12×3 4/9;
10×7 6/-; 16×9 8/-; 12×6 6/6.
Post 1/- per chassis extra.

FILAMENT TRANSFORMERS

All 200-250 v. 50 c.p.s. primary, finest quality, fully guaranteed.
6.3 v. 1.5 amp. 5/11
6.3 v. 3 amp. 9/6
6.3 v. 1 amp. 4/6
0-30 v. 2 amp. tapped voltages 19/6

R1155 RECEIVERS

Few only left. Let us have your enquiry. Prices from £7/19/6.

H.P. TERMS AVAILABLE on certain goods. *Write stating your requirements.*

FAMOUS AMPLIFIERS BUILT ON T.C.C. PRINTED CIRCUITS

MULLARD 510, ready for use. Price according to transformers used, from **15 gns.**

COMPLETE KIT and printed circuit, from 12 gns.

OSRAM 912, ready for use. Price according to transformers used, from **18 gns.**

COMPLETE KIT and printed circuit, from 15 gns.
Book of the Mullard 510, 3/6.
Book of the Osram 912, 4/-.

6-VALVE RADIOGRAM CHASSIS COMPLETE WITH VALVES

Famous Manufacturer's Surplus. 3-wave Superhet. 13-50 m., 200-550 m., 1,000-2,000 m. Brand new Mullard valves: ECH42, EF41, L63, EB41, 6V6, g.t. EZ40 and finest quality components. Overall size 13½ × 5in., height 12½in.
Price complete **£10.19.6**
Carr. and Pkg. 7/6 extra.

★ OUR NEW PORTABLE GRAM AMPLIFIER KIT

will soon be ready. Of very small dimensions and suitable for any type of mains operated portable record player. Price complete with valves, rectifier and 6in. × 4in. elliptical speaker will be under **£4**
DATA BOOK and shopping list, 1/6, post free.

TEST PRODS. Red and black, fused and retractable. Complete with fuses. Pair 2/11.

TRUVOX "SENIOR" SPEAKER DRIVING UNIT (pressure type)

New and unused in maker's cartons. Power handling capacity 15 watts peak. With a 12ft. cinema horn will reproduce down to 17 c.p.s. Listed at £7/15/-, LASKY'S PRICE 59/6. Carr. 5/-.

BRAND NEW AND PERFECT 16" METAL CONE C.R.T.

AT ENORMOUS SAVING

Convert to big picture television at a price you can afford. Note especially that these are not "seconds" but perfect tubes without fault, and supplied in original cartons. Brief specification: 6.3 v. heater, ion trap, 14 Kv. E.H.T., wide angle 70 deg., standard 38 mm. neck, duodecal base, magnetic focus and deflection. Maximum length 17⅜in. Gives large 11×14⅜in. black and white picture. GUARANTEED BY US FOR 3 MONTHS.

Full data, connections and suggested time bases supplied with every tube.

LISTED AT £23.9.10 **LASKY'S PRICE £8.9.6**

Carr. and Insur. 22/6 extra.

Masks, Anti-Corona, Bases and Ion Traps available.

LASKY'S FOR VALVES 20,000 IN STOCK

Here are a few examples of brand new surplus and imported valves:

EB91	7/6	EY41	10/6	EY51	12/6
EB41	7/6	EF80	10/6	EC84	11/6
EABC80	10/-	EF85	10/6	EY86	14/6
EAF42	10/-	EF86	12/6	EZ40	8/6
EBC41	10/-	EF91	9/6	EZ80	8/6
ECC85	10/-	6K8	10/6	PCF82	12/6
ECC84	15/-	6V6	9/6	PCC84	12/6
ECC83	9/-	6K7	5/6	PL81	13/6
ECC82	9/-	6Q7	10/6	PL82	10/6
ECC81	9/-	6R7	8/6	PL83	11/6
12AT7	8/6	5Z4	11/-	PY80	10/6
12AU7	8/6	DAF96	10/-	6AT6	7/6
12AX7	9/6	DL96	10/-	6AT7	7/6
ECF82	15/-	DK96	10/-	1S5	7/6
ECH42	11/6	DF96	10/-	3S4	7/6
ECH81	11/6	Set of 4	32/6	1T4	7/6
ECL80	11/6	DM70	9/-	IR5	7/6

Also full stocks of B.V.A. Valves and C.R. Tubes at the new lower list prices.
WRITE FOR COMPLETE LIST

MAKERS' SURPLUS T V COMPONENT BARGAINS

WIDE ANGLE 38 mm.

Line E.H.T. trans., ferrox-cube core, 9-16kV	25/-
Scanning Coils, low imp. line and frame	25/-
Ferrox-cube cored Scanning Coils and Line Output Trans., 10-15 kV., EY51 winding. Line Trans. incorporates width and linearity control. Complete with circuit diagram the pair	50/-
Frame Output Transformer	6/6
Scanning Coils low imp. line and frame	17/6
Frame or line blocking osc. transformer	4/6
Focus Magnets Ferrox-dure	19/6
P.M. Focus Magnets, Iron Cored	19/6
Duomag Focalisers	22/6
300 m/a. Smoothing Chokes	15/-
Electromagnetic focus coil with combined scan coils	25/-

STANDARD 35 mm.

Line Output Transformers 6.9 kV. E.H.T. and 6.3 v. winding. Ferrox-cube	19/6
Scanning coils. Low imp. line and frame	12/6
Ditto by Igranic	14/6
Frame or line blocking oscillator transformer	4/6
Frame output transformer	7/6
Focus Magnets: Without Vernier	12/6
With Vernier	17/6
Focus Coils, Electro-magnetic	12/6
200 m/a. Smoothing Chokes	10/6

MAINS TRANSFORMERS

All 200-250 v. 50 c.p.s. primary, finest quality, fully guaranteed.

MBA/3. 350-0-350 v. 80 mA., 6.3 v. 4 a., 5 v. 2 a. Both filaments tapped at 4 volts. 19/6

MBA/7. 250-0-250 v. 80 mA., 6.3 v. 3 a., 5 v. 2 a. Both filaments tapped at 4 volts. 19/6

AT/3. Auto trans. 0-10-120, 200-230-240 v. 100 watts. 19/6.

MT/340. Tapped input 200/250 v. 300-0-300, 100 mA., 5 v. 3 amp., 6.3 v. 1.5 amps. 16/6.

MT/341. Tapped input 250-0-250, 120 mA., 6.3 v. 5 amps., fully shrouded. 27/6.

LASKY'S (HARROW RD.) LTD.

LASKY'S RADIO

42 TOTTENHAM COURT ROAD, W.1.
Nearest Station Goodge Street
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370 HARROW ROAD, PADDINGTON, W.9.
(Opposite Paddington Hospital)
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Open all day Saturday. Early closing Thursday (both addresses)

ALL MAIL ORDERS TO HARROW ROAD PLEASE

R.S.C. BATTERY CHARGING EQUIPMENT

All for A.C. MAINS 200-250v., 50 c/s. Guaranteed 12 months

ASSEMBLED CHARGER
6 v. or 12 v. 2 amps.
Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads, Double Fused.
Only **47/9** carr. 3/6.

ASSEMBLED CHARGERS
6 v. 1 amp. 19/9
6 v. or 12 v. 1 amp. .. 25/9
6 v. 2 amps. 29/9
6 v. or 12 v. 2 amps. .. 38/9
6 v. or 12 v. 4 amps. .. 56/9
Above ready for use. Carr. 2/9.

HEAVY DUTY KIT
12 v. 30 amp. Suitable for garage or firm with a number of vehicles. Mains input 200/250 v. 50 c/s. Outputs 12 v. 15 amp. twice. Consists of Mains Trans. 2 Metal Rectifiers. 2 Meters. 4 Fuses. 4 Terminals. 2 Rheostats and circuit. Only 9 gns., carr. 15/-.

BATTERY CHARGER KITS
Consisting of Mains Transformer, F.W. Bridge, Metal Rectifier, well ventilated steel case, Fuses, Fuse-holders, Grommets, panels and circuit. Carr. 2/9 extra.
6 v. or 12 v. 1 amp. .. 22/9
6 v. 2 amps. 25/9
6 v. or 12 v. 2 amps. .. 31/6
6 v. or 12 v. 4 amps. .. 49/9

MAINS TRANSFORMER AND F.W. RECTIFIER
To provide mean charging rate of 5 amps. Circuit supplied. 42/6 plus 3/- carr.

Assembled 6 v. or 12 v. 4 amps.
Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging. Double fused. Well ventilated steel case with blue hammer finish. Ready for use with mains and output leads. Carr. 3/9.
69/6

SELENIUM RECTIFIERS

L.T. Types
2/6 v. ½ a.h.w. 1/9
6/12 v. ½ a.h.w. 2/9
F.W. Bridge Types
6/12 v. 1 a. .. 4/11
6/12 v. 2 a. .. 8/9
6/12 v. 3 a. .. 11/9
6/12 v. 4 a. .. 14/9
6/12 v. 6 a. .. 19/9
6/12 v. 10 a. .. 25/9
H.T. Type H.W.
120 v. 40 mA. 3/9
250 v. 50 mA. 5/9
250 v. 80 mA. 7/9
250 v. 150 mA. 9/9
300 v. 275 mA. 12/11

CO-AXIAL CABLE. 75 ohms, ½in., 8d. yard. Twin screened feeder, 11d. yard.

5 CORE FLEX. Henleys circular rubber 14/36. Each lead colour coded. 1/6 yd.

DIAL BULBS, M.E.S., 8 v. 0.2 a., 6/9 doz. 6.5 v. 0.3 a., 6/9 doz.

ELECTROLYTICS (current production). NOT Ex Govt.

Tubular Types		Can Types	
8 mfd. 450 v...	1/9	16 mfd. 350 v.	1/11
8 mfd. 500 v...	2/6	16μF 450 v. ..	2/9
16μF 350 v. ..	2/3	16 mfd. 500 v.	3/9
16μF 450 v. ..	2/9	32μF 350 v. ..	2/11
16μF 500 v. ..	3/9	32 mfd. 450 v.	4/9
8–16μF 500 v.	4/11	100 mfd. 450 v.	4/9
25μF 25 v. ..	1/3	8-8μF 450 v...	2/9
50μF 12 v. ..	1/3	8-16μF 450 v.	2/11
50 mfd. 25 v...	1/9	16-16μF 450 v.	3/11
50μF 50 v. ..	1/9	32-32μF 350 v.	4/9
100 mfd. 12 v.	1/9	32-32μF 450 v.	5/9
100 mfd. 25 v.	2/3	64-120 mfd. 350 v.	7/6
6,000 mfd. 6 v.	3/11	100-200 mfd. 275 v.	6/11

Many others in stock.

VOLUME CONTROLS with long spindles, all values, less switch, 2/9; with S.P. switch, 3/9.

EX GOVT. STEP UP/STEP DOWN TRANSFORMERS. Double wound 80/100 watts. 10-0-100-200-220-240 v. to 5-0-75-115-125-135 v. or Reverse. Only 11/9, plus 2/9 post.

EX GOVT. METAL BLOCK PAPER CONDENSERS

4 mfd. 500 v...	2/3	8 mfd. 500 v...	4/–
4 mfd. 1,000 v.	3/9	10 mfd. 500 v.	4/9
4 mfd. 1,500 v.	5/9	8-8 mfd. 500 v.	5/11
4 mfd. 400 v. plus 2 mfd. 250 v.			1/11

EX GOVT. VALVES. VR137, EA50, EB34, 11d.; SP61 2/3; 4SHA 1/3; EL32 3/9; VS110 1/11; KT44 4/9; 6J5 3/9; 6V6G, 5U4G 5/9; 6K7G, 2/11; 35Z4, 6X4 5/9; EZ80, EF80, 7/9.

EX GOVT. UNITS, type RDF1 in original sealed cartons with 14 valves including 5Z4G, etc., trans., L.F. choke, Rectifier, etc., etc. We cannot enter into correspondence regarding these units which represent a really exceptional bargain at 29/9. Carr. 7/6.

OIL FILLED BLOCK CONDENSERS
Bryce 11-7 mfd. 500 v. New unused Govt. surplus, only 5/9 each.

THE SKY FOUR T.R.F. RECEIVER

A design of a Long and Medium wave 3 valve 200-250 v. A.C. Mains receiver with selenium rectifier. For inclusion in cabinet illustrated above or walnut veneered type. It employs valves 6K7, SP61, 6F6G, and is specially designed for simplicity in wiring. Sensitivity and quality is well up to standard. Point-to-Point wiring diagrams, instructions and parts lists, 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite or veneered walnut.

EX. GOVT. MAINS TRANSFORMERS
All 230 v. 50 c/s. input
120-0-120 v. 40 mA. 5/9
300-0-300 v. 150 mA., 4 v. 3 a. 9/9
250-0-250 v. 80 mA., 6.3 v. 3 a., 6.3 v. 1 a. Potted 4½-3½-3in. 11/9
460 v. 200 mA., 6.3 v. 5 a. 22/9

MANUFACTURERS SURPLUS TRANSFORMERS
Fully shrouded upright. Primary 200-230-250 v. Sec. 425-0-425 v. 150 mA. 6.3 v. 3 a., 5 v. 3 a., 33/9. Drop through type tropicalised 250-0-250 v. 70 mA., 6.3 v. 2.5 a., 11/9. 230-0-230 v. 60 mA., 6.3 v. 2.5 a. Midget, 2½ × 3 × 2½in. approx., 11/9. Post 2/9 on any of above.

EX GOVT. SMOOTHING CHOKES
250 mA., 5 H., 50 ohms 12/9
250 mA., 3 H., 50 ohms 8/9
150 mA., 10 H., 50 ohms 10/11
150 mA., 6-10 H., 150 ohms, Topicalised 6/9
100 mA., 10 H., 100 ohms, Parmeko .. 6/9
100 mA., 5 H., 100 ohms, Topicalised.. 3/11
50 mA., 50 H., 1,000 ohms 6/9
L.T. type 1 amp., 2 ohms 2/9

SPECIAL OFFERS. Small 2 gang variables .0005 mfd., 4/9. 8-8 mfd., 450 v. Electrolytics (midget) in lots of six, 1/6 ea. 32-32-32 mfd., 250 v. 2½ × 1⅝ins. In lots of six, 2/3 ea.

MAINS ENERGISED SPEAKERS R.A. 2-3 ohms. 8in. Field 600 ohms., 10/9.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. **Suitable for all battery portable receivers requiring 1.4 v. and 90 v.** This includes latest low consumption types. Complete kit with diagrams 39/9, or ready for use, 46/9.

Type BM2. Size 8 × 5½ × 2½in. Supplies 120 v., 90 v., and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp. fully smoothed. **THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.T. 2v. ACCUMULATORS** when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator. Complete kit with diagrams and instructions 49/9 or ready for use 59/6.

MINIATURE MOTORS. 24/28 v. D.C. or A.C. Size only 2½ × 1½ins. Spindle 1½ins. long, ½in. diam. Made by Hoover Ltd., Canada. Price only 9/11.

VIBRATORS. Oak 2 v. 7 pin. synchronous, 7/9.

T.V. CABINETS. For 15, 16 or 17in. tube. Table model with doors, 79/6, carr. 7/6.

R.S.C. TRANSFORMERS

FULLY GUARANTEED. INTERLEAVED AND IMPREGNATED

MAINS TRANSFORMERS
Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING
250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a., Midget type, 2½-3-3in. 17/6
350-0-350 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a. 19/9
250-0-250 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a. 25/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 23/9
250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion 31/–
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 23/9
300-0-300 v. 100 mA., 6.3 v. 4 v. 4 a., c.t. 0-4-5 v. 3 a. 26/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 23/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a., suitable for Mullard 510 Amplifier 33/9
350-0-350 v. 100 mA., 6.3 v.-4 v., 4 a., c.t. 0-4-5 v. 3 a. 26/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a. 33/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a. 33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a. c.t., 5 v. 3 a., suitable Williamson Amplifier, etc. 49/9
450-0-450 v. 250 mA., 6.3 v. 6 a., 6.3 v. 6 a., 5 v. 3 a. 69/6

TOP SHROUDED DROP-THROUGH TYPE
260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v. 2 a. 16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a. 18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a. 22/9
300-0-300 v. 100 mA., 6.3 v.-4 v. 4 a., c.t., 0-4-5 v. 3 a. 23/9
350-0-350 v. 100 mA., 6.3 v. 4 a., c.t. 5 v. 3 a. 22/9
350-0-350 v. 100 mA., 6.3 v.-4 v. 4 a. c.t., 0-4-5 v. 3 a. 23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a. 29/9
E.H.T. TRANSFORMERS, 2,500 v. 5 mA., 2-0-2 v. 1.1 a., 2-0-2 v. 1.1 a., for VCR97, VCR517 ..... 36/6

FILAMENT TRANSFORMERS
Primaries 200-250 v. 50 c/s.
6.3 v. 1.5 a. .. 5/9
6.3 v. 2 a. .. 7/6
0-4-6.3 v. 2 a. 7/9
6.3 v. 3 a. .. 8/11
12 v. 1 a. 7/9
0-2-4-5-6.3 v. 4 a. 16/9
6.3 v. 6 a. .. 17/6
12 v. 3 a. or 24 v. 1.5 a... 17/6

CHARGER TRANSFORMERS
All with 200-230-250 v. 50 c/s. Primaries:
0-9-15 v. 1½ a., 11/9; 0-9-15 v. 3 a., 16/9;
0-3.5-9-17 v. 3 a., 17/9; 0-9-15 v. 5 a., 19/9;
0-9-15 v. 6 a., 23/9.

ELIMINATOR TRANSFORMERS
Primaries 200-250 v. 50 c/s.
120 v. 40 mA., 5-0-5 v. 1 a. 14/9
90 v. 15 mA., 6-0-6 v., 250 mA. 9/11

OUTPUT TRANSFORMERS
Midget Battery Pentode 66:1 for 3S4, etc. 3/6
Small Pentode 5,000Ω to 3Ω 3/9
Standard Pentode, 5,000Ω to 3Ω 4/9
Standard Pentode, 8,000Ω to 3Ω 4/9
Multi-ratio 40 mA. 30:1, 45:1, 60:1, 90:1, Class B Push-Pull 5/6
Push-Pull 8 Watts 6V6 to 5 ohms..... 8/9
Push-Pull 10-12 Watts 6V6 to 3Ω or 15Ω 15/9
Push-Pull 10-12 Watts to match 6V6 to 3-5-8 or 15Ω 16/9
Push-Pull 15-18 Watts, sectionally wound, 6L6, KT66, etc., to 3 or 15 ohms .. 21/9
Push-Pull 20 Watt high-quality sectionally wound, 6L6, KT66, etc., to 3 or 15Ω 47/9
Williamson type exact to spec. 85/–

SMOOTHING CHOKES
250 mA., 5 H., 100 ohms 11/9
150 mA., 7-10 H., 250 ohms 11/9
100 mA., 10 H., 200 ohms 8/9
80 mA., 10 H., 350 ohms 5/6
60 mA., 10 H., 400 ohms 4/11

R.S.C. A6 ULTRA LINEAR 30 WATT AMPLIFIER

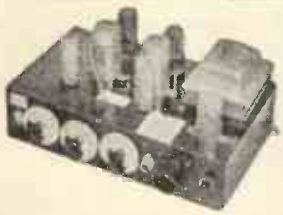
NEW 1956 DESIGN. HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. Tone Control Pre-amp stages are incorporated. Sensitivity is extremely high. Only 30 millivolts minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OF MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 a. FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams. **9 GNS.** Only carr. 10/-.

Or Factory built with 12 months' guarantee, 50/- extra. **TERMS ON ASSEMBLED UNITS** with extra input. **DEPOSIT** 28/9 and 9 monthly payments of 28/9. If required an extra input with associated vol. control can be provided so that two separate inputs such as "mike" and gram., etc., etc., can be simultaneously applied for mixing purposes. Extra cost of this 13/-. Cover as illustrated 17/6 extra.

Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 17 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE.** Frequency response ± 3 D.B., 30-20,000 c/cs., 12 D.B. "lift" at 50 c/cs., 12 D.B. "lift" at 12,000 c/cs., Hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue crackle. Overall size 12 × 9 × 9in. approx. Power consumption 150 watts. For A.C. mains 200-230-250 v. 50 c/cs. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS, or OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS, GARRISON THEATRES, etc., etc.**

We can supply Microphones, Speakers, Rotary Converters, etc., at keen cash prices or on terms with amplifiers.

EXPORT ENQUIRIES INVITED



R.S.C. TA1 HIGH QUALITY TAPE DECK AMPLIFIER

FOR ALL DECKS WITH HIGH IMPEDANCE RECORD/PLAYBACK AND ERASE HEADS. Such as Lane, Truvox, etc., or matched to low impedance erase heads as fitted latest COLLARO TAPE TRANSCRIPTOR. Chassis size 12-7-3in. Overall size 12-7-6½in. For 230-250 v. 50 c/cs. A.C. mains. Output for standard 2-3 ohm speaker. Only 15 millivolts input required for full recording. Only 2 millivolts minimum input required from recording head. Magic Eye recording level indicator. Provision for feeding P.A. amplifier. Can be used as gram. amplifier with input of 0.75 v. R.M.S. Negative feedback equalisation. Linear frequency response ± 3 D.B. 50-11,000 c/cs. Facilities for recordings at 15in., 7½in. or 3¾in. per second. Automatic equalisation at the turn of a knob. When switching from record to playback position automatic demagnetisation of heads is assured. PERFORMANCE IS COMPARABLE WITH UNITS AT OVER TWICE THE COST. LEAFLET 6d.

11 GNS. Ready for use Carr. 7/6

H.M.V. LONG PLAYING RECORD TURNTABLE COMPLETE WITH CRYSTAL PICK-UP (SAPPHIRE STYLUS). Speed 33⅓ r.p.m. BRAND NEW. CARTONED. Only £3/19/6 (approx. half price). Carr. 5/- (for 200-250 v. A.C. Mains).

R.S.C. 4-5 WATT HIGH GAIN AMPLIFIER TYPE A5

A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible. being 71 D.B. down, 15 D.B. of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-230-250 v., 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive. Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-point wiring diagrams and instructions. Exceptional value at only £3/15/-, or assembled ready for use 25/- extra, plus 3/6 carriage.

R.S.C. A7 3-4 WATT QUALITY AMPLIFIER

A highly sensitive 4-valve amplifier using negative feedback and having an excellent frequency response. Pre-amplifier and Tone Control stages are incorporated with separate Bass and Treble controls giving full tone compensation for Long Playing records. Suitable for any kind of pick-up including latest high fidelity types. H.T. of 250 v. 20 mA. and L.T. 6.3 v. 1 a. available for supply of Radio Feeder Unit, etc. ONLY 40 millivolts input required for full output. Fully isolated chassis with baseplate. For A.C. mains 200-250 v. 50 cycles. Output for 2-3 ohm speaker. Complete kit of parts with point-to-point wiring diagrams and instructions. Only £3/15/-, carr. 3/6 or factory built 28/6 extra.

P.M. Speakers recommended for use with above amplifiers.

Plessey 10in. 3 ohm with high flux density magnet. Only 28/9.

P.M. SPEAKERS. 2-3 ohm, 5in. Goodmans, 17/9, 7 × 4in. Elliptical, 19/6, 6½in. R.A., 15/9, 8in. Rola 19/9, 10in. R.A., 26/9, 12in. Plessey, 29/11. 12in. Plessey 10 ohms, 10 watts, 3 gns.

GARRARD 3-SPEED AUTOMATIC RECORD CHANGERS.

Latest Model Mixer Type RC110. Fitted high fidelity turnover crystal pick-up head with dual point sapphire stylus. Baseboard size 14 × 12½in., height above, 4in. Below, 2½in. For 200-250 v. A.C. mains. Limited number. Brand new cartoned. Only £7/19/6, plus 3/6 carriage.

LINEAR MINIATURE 4/5 WATT QUALITY AMPLIFIER. Suitable for use with Garrard B.S.B. or any other record playing unit, and most microphones. Total negative feedback 18 db. Separate Bass and Treble Controls. For convenience when mounted in cabinet, mains switch is incorporated in control. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves used. Size of unit only 6 × 5 × 5½in. high. Chassis is fully isolated from mains. Guaranteed 12 months. Only £5/19/6.

MICROPHONES. High fidelity crystal types. Acos 33-1 hand or desk type, 50/-. Piezzo with heavy floor base and telescopic tem, £6/19/6.

RCA 20 WATT RE-ENTRANT SPEAKERS. For 15 ohm or 600 ohm matching. Brand New. Ideal for any outdoor work. Only 8 Gns.

PLESSEY DUAL CONCENTRIC 12 in. P.M. SPEAKERS

(15 ohms), consisting of a high quality 12in. speaker, of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A8 or any similar amplifier. Rating is 10 watts. Price only £5/17/6.

R.S.C. ULTRA LINEAR 12-WATT AMPLIFIER

NEW 1956 MODEL A8 HIGH-FIDELITY PUSH-PULL AMPLIFIER WITH "BUILT-IN" TONE CONTROL, PRE-AMP. STAGES

High sensitivity. Includes 5 valves (807 outputs), High Quality sectionally wound output transformer, specially designed for Ultra Linear operation, and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut." Frequency response ± 3 db. 30-30,000 o/cs. Six negative feedback loops. Hum level 71 db. down. ONLY 70 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and practically all microphones. Comparable with the very best designs. For STANDARD or LONG PLAYING RECORDS. For MUSICAL INSTRUMENTS such as STRING BASS, GUITARS, etc. OUTPUT SOCKET with plug provides 300 v. 20 mA. and 6.3 v. 1.5 a. For supply of a RADIO FEEDER UNIT. Size approx. 12-9-7in. For A.C. mains 200-230-250 v. 50 c/cs. Output for 3 and 15 ohm speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied.

Unapproachable value at **£7/15/-** or factory built 45/- extra. Carriage 10/-. If required louvred metal cover with 2 carrying handles can be supplied for 17/6. Where an extra input socket with associated volume control is required for mixing purposes this can be provided for 13/- extra. TERMS ON ASSEMBLED UNITS with extra input as mentioned above. DEPOSIT 25/6 and nine monthly payments of 22/4.

LINEAR "DIATONIC" 10-WATT HIGH FIDELITY AMPLIFIER. Incorporating pre-amp. For A.C. Mains input 200-230-250 v. 50 c.p.s. A compact attractively finished unit with two separately controlled inputs, and outputs for 3 and 15 ohm speakers. Separate Bass and Treble controls. Five latest type miniature Mullard valves. Only 12 Gns. Carr. paid. Send S.A.E. for leaflet.

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS. HF1012, 10 watts, 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance, £4/10/9. Please state whether 3 ohm or 15 ohm required.

SUPERHET FEEDER UNIT

Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode F/changer is used. Pentode I.F., and double Diode Second Detector. Delayed A.V.C. Ae./Grid F/C Coupling is by bottom end Condenser Coupling giving freedom from alignment troubles when Ae. of varying lengths and capacity are used. Both Frequency Changers and I.F. valves are A.V.C. controlled from the very low distortion Double Diodes so arranged that very high Percentage modulation of the Transmitter can be handled without distortion. The Feed for the delayed A.V.C. is arranged so that A.V.C. distortion is avoided. The W. Ch. Sw. incorporates Gram. position. Controls are Tuning, W., Ch., and Vol. Output will load most Amplifiers requiring 500 MV. input depending on Ae. location. Only 250 v. 15 mA. H.T., and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7in. high. Send S.A.E. for illustrated leaflet. Total building cost is £4/15/-. Point-to-Point wiring diagrams and instructions, 2/6.

Radio Supply Co. (LEEDS) LTD.

32 THE CALLS. — LEEDS, 2.

Terms C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/9 extra on *all* orders under £2, 2/9 extra under £5 unless carriage charge stated. Full Price List 6d. Trade List 5d. Open to Callers: 9 a.m. to 5.30 p.m. Saturday until 1 p.m.

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A room-to-room telephone . . .

Ideal for two-way conversation, house-to-garage or internal communication.

- No batteries required
- No soldering required
- Just connect it up and it works

The sets consist of 2 high-quality microphone/receivers (new and boxed) and 15 yards of twin wire.

COMPLETE FOR **8/6**
plus 1/6 postage

R1155 RECEIVERS

Air Tested, in good secondhand condition. Price £6/5/-, plus 10/- packing and carriage.

TWIN COUNTERS

(Gallons gone) 24V, reading 4 figures and reset contained in housing, size 4in. dia. by 5in. long, 15/- plus 2/- p.p.

NICKEL IRON CELLS

1.2 volt, size 3¼in. × 2¾in. × 1in., unfilled 5/- each, plus 1/- p.p.

AN/APN.1 TRANSDUCER

This Unit consists of Magnet, and Coil which is attached to an aluminium diaphragm suspended freely and perforated to prevent air damping. Mounted on a Ceramic cover which sits over the diaphragm is a form of 2-Gang capacitor which has a swing from 10-50 pF.

The above unit is used as part of Wobbulator described on page 252 of the June "Wireless World." PRICE 7/6 p.p.

GRAM MOTORS

A.C. mains (B.S.R.), brand new and boxed 19/6 p.p.

ALTITUDE SWITCHES

(U.S. manufacture) containing a double pole 11-way switch (Yaxley type) and 14 2.5 K ohms 1 watt resistors 10% contained in metal box 3in. dia. by 5in. long with 1½in. skirted pointer knob. Brand new and boxed 4/- p.p.

MINIATURE I.F. STRIPS

Size 10¾ × 2½ × 3in. Frequency 9.72 Mc/s. 2 EF.92s and 1 EF.91 I.F. amps. EB.91. DET/AGC. EF.91 AGC. Amp. and EF.91 Limiter. Circuit supplied.

Price 8/- less valves. Post paid.

BATTERY CHARGING LEADS

2 yds. of cab tyre twin cable, and 2 large crocodile clips; new and boxed 3/- p.p.

INDICATOR LAMPS

American panel type complete with 6 v. bulbs in set of 4, 3 green jewels and 1 red jewel, 10/6 post paid.

TRANSMITTER Type T1131-L

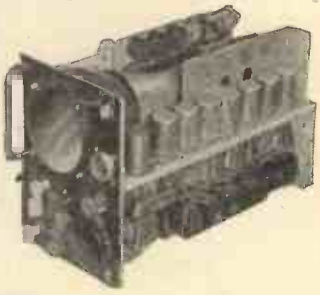
Frequency 100 to 156 Mc/s. Output 50 W. Crystal controlled. 200-240 v., 50 c.p.s. Power supply. Housed in 6ft. standard on 19in. rack. In new condition complete with valves.

Send for full details.

APQ.2. RADAR/JAMMING UNIT

Freq. 450-710 Mc/s. Containing 931a Photo Multiplier Cell complete with resistance network and light proof box. Wide band amplifier 2 6AC7, 1 6AG7, 2 388a. This unit is similar to the A.P.Q9 Jamming Unit. **Brand new £5** plus 10/- carriage.

TYPE 62A INDICATORS



Ideal for conversion to oscilloscopes, T.V. units, etc. Containing VCR.97, 12 VR.91 (EF.50), 2 VR.54 (EB.34), 3 VR.92 (EA.50), 4 CV.118 (SP.61). Slow-motion dial, 13 Pots and scores of useful components. Size 8½ × 11½ × 18in. In wooden packing case, **£3**, carriage 7/6.

BENDIX TRANSMITTERS

TYPE T.A. 12B Master oscillator type transmitter. 4 channel 40 W. operation provide telephone, CW or MCW in frequency ranges of 300-600 kc/s, 3-4.8 Mc/s., 4-6.4 Mc/s., 4.37-7 Mc/s. Each of the 4 channels has its own oscillator and uses a 12SK7. The IPA stage consists of an 807, while the PA is two 807s in parallel. Size 10½in. × 6¾in. × 15½in. Price £3/15/-, plus 10/- carr.

INVERTERS

Miniature 3-phase (ex-compass unit) 24 v. input with 17 v. 3-phase, 400 c/s. output. These have been used by model makers as motors and are known as the "5/- Motor." Will run quite successfully on 12 volts. 5/- plus 2/- p.p.

POWER UNIT Type 173

24 volt D.C. input, 120 v., 60 mA. output. Containing Vibrator Transformer, 12 volt Vibrator, two 120 volt Selenium Rectifiers. Chokes and Condensers. Size 10½in. × 6in. × 3in. Price 12/6 post paid.

2in. MAGSLIPS

50 v. 50 cycle transmitter and receiver units. Accurate to 1/10th deg. Guaranteed good working order, 35/- a pair, plus 3/- p.p.

MORSE SIGNALLING LAMPS

(Aldis type) 5in. dia. with sighting arrangement, 2 handles, keying switch, and 2 yards cable. In wood carrying case, 10/- plus 3/- p.p.

SPECIAL OFFER

MALLORY VIBRATOR PACKS

12 volt, 150 volt 40 mA. Brand new and boxed, size 5½in. × 5¼in. × 3in., 12/6 each p.p.

EARPIECES

2,000 ohm C.H.R. or balanced armature type, low resistance single units 3/6 each, plus 6d. p.p.

STUD SWITCHES

20 segment 5/16in. studs, base 5in. square with handle and housing. New and boxed, 5/- each, plus 1/6 p.p.

POST OFFICE COUNTERS

500 ohm, 4 figure. no reset; size 5 × 1¾ × 1in. 5/- each, p.p.

All these fine offers are on display at

PROOPS BROS. LTD. — *The Walk-around Shop*

R.F. UNITS

R.F.24 20-30 Mc/s. Switched Tuning. Valved 9/6 each.

R.F.25 40-50 Mc/s. Switched Tuning. Valved, 9/6 each.

R.F.26 50-65 Mc/s Variable tuning, valved. Damaged dials 20/- each; perfect dials 25/- each.

Packing and postage 3/- each.

CR.300/1 RECEIVER & POWER SUPPLIES

Available for callers only.

RECTIFIERS

Chassis cooled, brand new, 125 volt, 80 mA., 4/9 p.p.; 250 volts, 50 mA. 8/3 p.p.

BEACON RECEIVER BC-1206-A

Covering 200-400 Kc/s. Valve line up: 6K7 R.F.; 65A7 frequency changer; 6SK7 I.F. amplifier; 6SQ7 det.; 28D7 O/P. This was designed to run on 24/28 V. D.C. HT/LT. Excellent basis for car radio. Size: 6×5×4in. Good working order. £3/5/- each plus 3/- carr.

VALVE TESTERS

MODEL 314

This model is of American manufacture and versatile, free-point return valve tester. Its design is such that it enables the user to test any type valve, regardless of its filament voltage or base wiring. Flexibility is attained by using individual lever switches for each valve element. Complete coverage of American Series including Acorns.

PRICE: **£10** Plus 10/- carriage.

REFLECTOR (RADAR)

Dinghy type 3×3×3ft. aluminium struts and 12 wire mesh planes. Originally used as a device for rescue detection. Brand new and boxed 4/- plus 2/- p.p.

MARCONI RECEIVER B29

Frequency 15-560 Kc/s in 4 bands. Brand new £10 plus £1 p.p.

3 cm. TEST SET

TYPE 263

Containing transmission type w/meter complete with detector unit 9280-9480 Mc/s, attenuator unit, 2 coaxial to waveguide feeders, impedance matching unit, medium power dummy load, standing wave indicator with lock using CV.263 indicator valve, metered indicator unit, various connectors. Suitable for testing medium and low power radar installations. Price **£20** carriage paid.

WAVEMETER TYPE W.1310

Coverage 155 to 230 Mc/s. continuous, complete with Test Prod. Input 230 v. 50 cycles. New condition, £3/10/-, plus 7/6 carr.

SMALL MAINS TRANSFORMERS

Input 230 volt 50 cycles, output 250 volt 40 mA., 6.3 volt 1.5 amp. Size 3.9 × 2.4 × 2in. Ideal for TV converters. Price 12/6 each, plus 1/- p.p.

CHARGER TRANSFORMERS

For 6 or 12 volt, 230 volt 50 cycles input, 9 and 17 volt 3 amp. output. Price 15/6 each, plus 1/- p.p.

HEATER TRANSFORMERS

6.3 volt, 1½ amp. Brand new, 6/6 each plus 1/- p.p.

I.F. AMPLIFIER UNIT

460 kc/s. with IT4. Brand new and boxed. Fully screened in plug-in box. Size 2¼in. × 1in. × 4¼in.

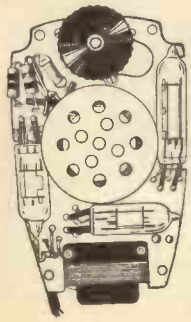
Price, with circuit, **10/-** each, plus 1/- p.p.

THROAT MICROPHONES

Type T30. U.S. Manufacture

Complete with elastic strap. Lead terminating at 2-pin plug PL.291, and socket JJ-048. New and boxed, 3/- each, post paid.

Make a miniature POCKET RADIO



Incorporating high "Q" technique using the New Ferrite rod. Made possible by simple conversion of an ex-Govt. Hearing Aid, size: 3¾×2½×1in.

Technical Details. A Germanium Diode Detector circuit followed by the existing 3 valve Amplifier, giving adequate amplification throughout the medium wave band.

This conversion can be carried out in approximately 30 minutes.

SEE and HEAR this Miniature POCKET RADIO demonstrated.

THE COMPLETE KIT OF PARTS includes a Type OL10 Hearing Aid (with Crystal microphone) in perfect working order with miniature earphone and moulded ear insert attached; ferrite rod, germanium diode, components, circuit diagram and full instructions.

PRICE **£2 6s. 0d.** Post paid

ALL COMPONENTS SOLD SEPARATELY

Deaf Aid Unit with earpiece..	£1 15 0
Plastic Ear mould	2 0
Ferrite Rod	5 0
Conversion Components	4 0
Batteries 1.5v L T (Type D 18)	8
30 v H T (Type B 119)....	4 3

NOTE: As the crystal microphone is not used in the Pocket Radio, it can, if desired, be used as a general microphone and it does not require a matching transformer.

NOTE: Carriage prices quoted apply only to England and Wales.

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RECORDERS
TAPE AMPLIFIERS

STERN'S

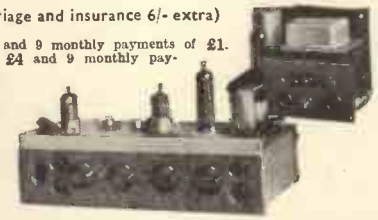
RECORD PLAYERS
AMPLIFIERS

HIGH FIDELITY RECORDER EQUIPMENT FOR THE CONSTRUCTOR

The "fidelity" TAPE AMPLIFIER Model HF/TR2 WITH POWER SUPPLY UNIT

Price £16.0.0 (Carriage and insurance 6/- extra)

H.P. TERMS: Deposit £8 and 9 monthly payments of £1. CREDIT TERMS: Deposit £4 and 9 monthly payments of £1/10/8.



This amplifier has been expressly designed to meet the requirements of the enthusiasts for High Fidelity reproduction. It is based on a new design, completed by the Mullard Technicians and only really high grade components are incorporated, truly HIGH FIDELITY Recordings are obtainable whilst "Hi Fi" reproduction is assured by use of a high quality Output Transformer by Gilson. It incorporates a "magic eye" Recording Level Indicator, a two position equaliser for 3¾in. and 7½in. speeds, and an effective Tone Control arrangement. Monitoring and Extension Speaker Socket are incorporated and in addition a position is provided to enable it to be used as an independent Amplifier for Gramophone Records or Radio Tuning Unit. Overall size: 11in. × 6in. × 6in. high.
When ordering, please advise make of deck in use.

Send S.A.E. for full details

A complete kit of parts to build this amplifier and power unit will be available mid-March. Price £12.

OTHER TAPE RECORDER EQUIPMENT IN STOCK

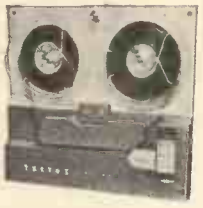
(a) The BRENELL 3 speed Tape Deck £18/18/-.
(b) The LUSTRAPHONE MOVING COIL MIKE HIGH IMPEDANCE £3/7/6.
(c) The ACOS CRYSTAL MIKE, HIGH IMPEDANCE £2/10/-.
(d) The TRUVOX MODEL "C" TAPE AMPLIFIER £17/17/-.
(e) The ARMSTRONG P.A.B.O. TAPE PREAMPLIFIER £12/10/- (suitable for nearly all tape decks).

All types of PLASTIC TAPE by E.M.I., SCOTCH BOY and GRUNDIG, Standard and Long play ARE IN STOCK.

HIRE PURCHASE and CREDIT TERMS are available on all above equipment.

THE NEW TRUVOX MkIV TAPE DECK

THIS IS UNDOUBTEDLY ONE OF THE BEST TAPE DECKS ON THE MARKET. WE HAVE A FEW ONLY AVAILABLE.



PRICE £25 . 10 . 0
(Plus 10/- carr. and ins.)
EXCLUDING COUNTER

CREDIT TERMS: Deposit £6/7/6 and 9 monthly payments of £2/6/9.

H.P. TERMS: Deposit £12/16/0 and 12 monthly payments of £1/3/8.

SPECIFICATION:— ● 3 B.T.H. shaded pole motors with silent friction drive eliminating "wow" and "flutter." Limits on tape travelling speed variation have been kept down to an absolute minimum. ● Push button controls, electrically and mechanically interlocked (patented). ● Patented electric type push button controlled brake. ● Facilities: Record; playback; fast forward; fast reverse (a complete 1,200ft. reel can be re-spooled in less than one minute); inching to assist editing; tape loading on the drop-in principal; accommodation for reels of 7in. diameter containing 1,200ft. of standard tape or 1,800ft. of thin tape. ● Tracking sense. To British and American standards. A conversion set, TR.2028, will convert the machine to Continental playing standards. ● Playing times: (Up to 3 hours with L.P. Tape) 60 minutes per track at 3¾in. per second for standard tape; 90 minutes per track for long playing tapes; 30 minutes per track at 7½in. per second for standard tapes; 45 minutes per track for long playing tapes. ● Two tracks, side by side, with safety gap. ● Playing time indication by precision revolution counter or large visual type indicator plate, according to choice. Positive Azimuth adjustment of Record/Player Head. With a suitable amplifier, the equipment covers a frequency range from 50-12,000 cps. at 7½in. per second. ● High Impedance Heads are designed for Supersonic Bias and Erasing from a common oscillator. No matching transformers are required. ● The panel has a washable finish that is highly resistant to any form of mechanical damage; the metal work is Gold Hammered finish. ● Overall size 14½in. × 12⅝in., from top of face of panel, overall depth 5in. Weight 14½lb.
WE ALSO HAVE A FEW DECKS WITH REV. COUNTERS Price £29.

HOME CONSTRUCTORS

WE MAKE SPECIAL PRICES TO PURCHASERS OF TAPE EQUIPMENT (i.e. buyers of Deck and Amplifier together etc., etc.) . . . SEND YOUR ENQUIRY TO Us . . . H.P. and CREDIT SALE TERMS ARE AVAILABLE.

PORTABLE CASE

IDEAL FOR RECORD PLAYERS

Price Only £3.3.0
(Plus 3/- Carr. & ins.).

Attractively finished in High Grade Rexine and Robustly constructed with initial measurements at 13¼in. × 15¼in. high. It will be seen therefore that it will accommodate all makes of Record Players including Autochangers. An uncut baseboard is also supplied.

STERN'S "COMPACT 5" AMPLIFIERS

The "Compact 5-2"

EXPRESSLY DEVELOPED FOR VERY HIGH QUALITY REPRODUCTION OF GRAM. RECORDS AND PARTICULARLY SUITABLE FOR HIGH QUALITY REPRODUCTION OF THE F.M. TRANSMISSIONS.

A 2-stage high sensitivity amplifier having SEPARATE BASS and TREBLE CONTROLS and designed to give up to approx. 5 watts with very pleasing quality. PRICE £6/ 6/-.

The "Compact 5-3" A 3-stage version of the "5-2" model but in this case having an additional stage and incorporating negative feedback. PRICE £8/16/-.

The Amplifiers are compact and very attractively designed having a "Hammered Gold" finish with a fully engraved front panel by which the entire Amplifier is conveniently mounted into a Cabinet, occupying no more space than a conventional Tone Control Unit. Send S.A.E. for illustrated Leaflet.

POWER SUPPLY. Is obtainable from a small separate Unit which apart from supplying power to either Amplifier, also has additional supply available for a Radio Tuning Unit. PRICE (additional to above), £2/10/-.

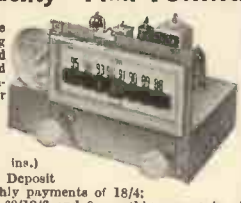
A GENERAL PURPOSE GRAM AMPLIFIER

HAVING SEPARATE BASS and TREBLE CONTROLS

Price assembled and ready for use
£4 . 5 . 0
(Plus 5/- Carr. & Ins.).

This model has been designed to meet the demand for a small Amplifier providing GOOD QUALITY REPRODUCTION in particular Gram Records. It incorporates an EL84 in the output stage for approx. 3 watts. The three controls (Bass, Treble and Volume) are left on "floating" leads thereby making for easy accommodation in almost any case or cabinet. Overall size 7in. × 6¼in. × 2¼in.

Stern's "fidelity" F.M. TUNING UNIT



A 5-Valve Tuner incorporating the latest Mullard Permeability Tuned Unit. Price assembled less Power Supply:

£14.10.0
(Plus 7/6 carr. & ins.)

TERMS: (a) H.P. Deposit £7/5/- and 9 monthly payments of 18/4;
(b) Credit Deposit £3/12/6 and 9 monthly payments of £1/6/7. Provides "Hi-Fi" reproduction with any make of Amplifier and many Radio Receivers. It incorporates: ● The latest Valve line-up—ECC85, 2 type EF85, EF91 and EM80. ● A "Magic Eye" Indicator. ● Power consumption is 1.7 amps. at 6.3 volts and 25 m/a. at 250 volts.

STERN'S "fidelity" COMBINED A.M. and F.M. TUNING UNIT

This is IDENTICAL to the Stern's F.M. Tuner illustrated above, but in addition incorporates the MEDIUM WAVEBAND and thereby also provides a selection of foreign stations.

Price £18.18.0 (Plus 7/6 carr. and ins.)

TERMS:—(a) H.P. Deposit £9/9/- and 10 monthly payments of £1/1/-; (b) Credit Deposit £4/15/- and 9 monthly payments of £1/14/7. Send S.A.E. if further data required.

THE ARMSTRONG MODEL AF105 AM/FM RADIOGRAM CHASSIS

Developed to meet the needs of those who require really high quality radio and record reproduction but who, for reasons of expense or lack of room in existing or proposed cabinets, cannot consider the normal high-fidelity system. The A.F.105 is as good as, or better than, all but the most expensive Amplifiers, and Associated units. Independent and continuously variable Bass and Treble controls give a wide range of control.
SEND S.A.E. FOR DETAILS.

PRICE £37 (Plus 7/6 Carr. & Ins.).

CREDIT SALE TERMS: Deposit £9/5/- and 9 monthly payments of £3/7/10.
HIRE PURCHASE TERMS: Deposit £18/10/- and 12 monthly payments of £1/14/4.

THE LEAK "TL/10" AMPLIFIER and "POINT ONE" PREAMPLIFIER

Provides a maximum output of 10 watts, maintains in every respect the renowned Leak reception for precision engineering, fine appearance and fastidious wiring. PRICE COMPLETE £28 . 7 . 0
(Plus 7/6 carr. and ins.)

TERMS: Credit: Deposit £7/7/- and 9 monthly payments of £2/11/4. H.P. Deposit £14/4/- and 12 monthly payments of £1/6/-. Send S.A.E. for fully illustrated leaflet.

Open Monday to Friday 9 a.m.—6 p.m.
Saturday 9 a.m.—1 p.m.

STERN RADIO LIMITED

AMPLIFIERS
PRE-AMPLIFIERS

HIGH FIDELITY FOR THE HOME CONSTRUCTOR

TUNING UNITS
RADIO RECEIVERS

—COMPLETE KITS OF PARTS FOR THE "Hi-Fi" ENTHUSIAST—

QUALITY OF THIS NATURE HAS NEVER BEFORE BEEN OFFERED AT SUCH LOW COST.

The MULLARD '5-10' MAIN AMPLIFIER

This is the very latest design and needs no recommendation from us. Our Kit is complete to Mullard's specification, including the latest GILSON ULTRA LINEAR OUTPUT TRANSFORMER and the entire MULLARD Valve line up. ALL SPECIFIED COMPONENTS are supplied.

PRICE OF COMPLETE KIT OF PARTS (Plus 5/- carr. and ins.). **£11/11/0**

STERN'S "fidelity" PRE-AMPLIFIER TONE CONTROL UNIT

"A design for the music lover"

Briefly it has inputs for all types of MICROPHONES, HIGH and LOW GAIN PICK UPS and a RADIO TUNING UNIT. It incorporates (a) GRAM EQUALISING CONTROL. (b) STEEPCUT FILTER; (c) Continuously variable BASS and TREBLE CONTROLS and a variable OUTPUT CONTROL which enables its use with any type of Amplifier.

PRICE OF COMPLETE KIT OF PARTS **£6/6/0**

WE ALSO OFFER IT ASSEMBLED READY FOR USE, £8/-/- (Plus 5/- carr. and ins.).

THE full SPECIFICATION and BUILDING INSTRUCTIONS for these three Units are available for 1/6 each. THEY include COMPONENT PRICE LISTS and simple "wire-to-wire" PRACTICAL DIAGRAMS.

A COMPLETE KIT OF PARTS STERN'S "HIGH QUALITY" 8-10 WATT AMPLIFIER

Has power supply available for Radio Tuning Unit.

Price of COMPLETE KIT OF PARTS (plus 5/- carr. and ins.). **£7/10/0**

WE ALSO OFFER IT ASSEMBLED and READY FOR USE for (plus 5/- carr. and ins.). **£9/10/0**

This amplifier has proved one of the most popular models yet offered to the HOME CONSTRUCTOR. It provides really excellent reproduction up to 8 watts, employing 6V6's in push-pull and incorporating negative feedback. Provides for the use of both 3 and 15 ohm Speakers. The Complete SPECIFICATION and BUILDING INSTRUCTIONS are available for 1/6.

"Wire-to-Wire" Diagrams are included and all Components are available separately.

SPECIAL PRICE REDUCTIONS . . . FOR PURCHASERS OF A COMPLETE "Hi-Fi" AMPLIFIER

WE WILL SUPPLY (a) COMPLETE KIT OF PARTS to build THE MULLARD "5-10" MAIN AMPLIFIER and the STERN'S "fidelity" PRE-AMPLIFIER-TONE CONTROL UNIT for £16/16/- or we will supply THE TWO UNITS MADE UP and READY FOR USE for £19/19/-. Terms: Deposit £9/19/6 and 12 monthly payments of 18/7, or £5 Deposit and 9 monthly payments of £1/16/7.

"MODERNISE YOUR OLD RADIOGRAM"

IT IS MUCH CHEAPER THIS WAY!!

THE LATEST DESIGN OF COMBINED AM/FM REPLACEMENT RADIOGRAM CHASSIS and a NEW 4-SPEED RECORD PLAYER

STERN'S NEW "Fidelity" COMBINED AM/FM RADIOGRAM CHASSIS

A genuinely hand-made chassis providing really high quality on both Radio and Gram.

PRICE **£26/15/0** (Plus 7/6 carr. and ins.).

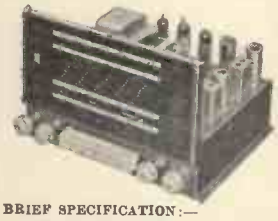
TERMS: Credit Deposit £6/14/- and 9 monthly payments from £2/9/-. H.P. Deposit £13/7/6 and 12 monthly payments of £1/4/10.

BRIEFLY IT HAS:—

An 8 valve line up incorporating the latest MULLARD preferred-type valves. ● Provides complete coverage of the VHF/FM waveband plus the SHORT, MEDIUM and LONG waves. ● Has EL84's in Push-Pull, with negative feedback of 6 watts output. ● Employs "Piano Key" Selector Switch and a Variable Tone Control. ● Contains Gram input socket for both Crystal and Magnetic Pick-ups. ● Provides for use of either 3 or 15 ohm Speakers. ● Has "Magic Eye" Tuning Indicator. ● Dimensions 13in. × 9¼in. × 8in. high, Dial size 11¼in. × 5¼in.

THE NEW ARMSTRONG P.B.409 AM/FM RADIOGRAM CHASSIS

A "de luxe" Chassis for those who want the highest possible quality



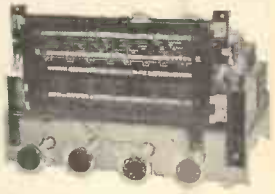
PRICE **£29/8/0** (Plus 7/6 carr. and ins.).

TERMS: Credit Deposit £7/7/- and 9 monthly payments of £2/14/-. H.P. Dep. £14/14/- and 12 monthly payments of £1/7/3.

BRIEF SPECIFICATION:—

A 9 valve line up employing the latest MULLARD preferred-type valves. ● Provides complete coverage of the VHF/FM Transmissions, plus the SHORT, MEDIUM and LONG waves. ● Has Push-Pull output, with negative feedback, for 6 watts Peak output. ● Quick action "Piano Key" Selectors and separate Bass and Treble Controls. ● Has "Magic Eye" Tuning Indicator. ● Two Gram Inputs are provided, one for Crystal Pick-ups and the other for Magnetic types. ● Dimensions 13in. × 9¼in. × 8in. high, Dial size 11¼in. × 5¼in.

STERN'S "SUPER SIX" 6 Valve 3 Waveband Superhet



Provides good selection of stations and really good reproduction on both RADIO & GRAM.

PRICE ONLY **£14.0.0** *(Plus 7/6 carriage and ins.)*

CREDIT TERMS: Deposit £3/10/- and 9 monthly payments of £1/5/8. H.P. TERMS: Deposit £7 and 10 monthly payments of 16/-.

BRIEF SPECIFICATION . . .

★ Delayed AVC on all wavebands
★ Preselection feedback
★ Modern valve line-up: 12AH8, 6BA6, 6AT6, two 6AQ5s and 5Z4 (or OCTAL VALVE equivalents)
★ Push-pull output gives approx. 6 watts
★ Connections on chassis for extension speaker, gram. and mains supply to gram.
★ Coverage 18-50 metres, 190-560 and 800-2,000
★ Overall size 11 × 7½ × 8¼in. high, dial 8½ × 4¼in.
★ A bronze dial escutcheon is available for 4/6.

SEND S.A.E. IF FURTHER INFORMATION IS REQUIRED ON THESE CHASSIS.

To complete a GENUINELY HIGH QUALITY RADIOGRAM . . . we recommend THE NEW COLLARO MODEL 456 4-speed Autochanger, and if a LOUDSPEAKER is required . . . we recommend THE 8- or 10-inch W.B. STENTORIAN "Hi-Fi" MODELS. We have SPECIALLY REDUCED PRICES for purchasers of a CHASSIS and RECORD PLAYER (and SPEAKER if required). SEND S.A.E. FOR DETAILS.

CASH ONLY OFFER!!

This latest B.S.R. MONARCH 4-SPEED AUTOCHANGER

£8/15/0 (Plus 5/- carr. and ins.).

● These units will autochange on all three speeds, 7in., 10in. and 12 in.

● They play MIXED 7in., 10in. and 12in. records of same speed.

● They have separate sapphires for L.P. and 78 r.p.m., which are moved into position by a single switch.

● Minimum baseboard size required 14 × 12½in., with height above 5¼in., and height below baseboard 2¼in. A bulk purchase enables us to offer these BRAND NEW UNITS at this exceptional price.

RECORD PLAYERS

THE VERY LATEST MODELS ARE OFFERED AT GREATLY REDUCED PRICES

● TRANSCRIPTION UNITS. ● 3- and 4-SPEED AUTOCHANGERS ● AUTOCHANGERS with MANUAL CONTROL POSITION. Send S.A.E. for ILLUSTRATED and DESCRIPTIVE LEAFLET.

STERN'S POWER SUPPLY UNITS

Two Units are available. TYPE "A" UNIT . . . Incorporates type 6X5 Valve and provides 250-300 volts at up to 70 mA. and 6.3 volts at 3½ amps.

PRICE OF COMPLETE KIT OF PARTS **£2/9/6**

ASSEMBLED AND READY FOR USE **£2/17/6**

(Carriage and insurance 2/6 extra)

TYPE "B" UNIT. Incorporates type EZ81 valve and provides 250-300 volts at up to 100 mA. and 6.3 volts at 3½ amps.

PRICE OF COMPLETE KIT OF PARTS **£2/15/0**

ASSEMBLED AND READY FOR USE **£3/3/0**

(Carriage and insurance = 2/6 extra)

The WIRING DIA [illegible] AMPS AVAILABLE SEPARATELY FOR 9d. It conta[illegible]s all relative data.

FOR CALLERS ONLY

We have in stock various KITS OF PARTS including F.M. Tuners, AM/FM Tuners, Midget Battery Portable and Mains Units, etc., etc. . . . We also have the most comprehensive stock of WIRELESS and ELECTRICAL COMPONENTS.

SPECIAL CASH ONLY OFFER!!

A PORTABLE AMPLIFIER CASE

A good quality 2 Stage (plus Rectifier) GRAM AMPLIFIER together with a 6½in. P.M. Speaker and this attractive PORTABLE CASE.

ALL FOR ONLY **£8.7.6.** The Amplifier incorporates the latest B.V.A. Valves, types ECC83, EL84, with EZ80 Rectifier and has separate BASS and TREBLE CONTROLS. The CASE is attractively finished in Rexine, maroon and grey, and has space for almost any make of Autochanger. We also sell the two separately:

(a) AMPLIFIER and 6½in. SPEAKER £4 12 6

(b) PORTABLE CARRYING CASE £3 17 6

109-115 FLEET ST., LONDON, E.C.4.

Phone: FLEet Street 5812-3-4

CLYNE RADIO LTD.

18, TOTTENHAM COURT ROAD, LONDON, W.1

MUSeum 5929/0095
(50 yards only from Tottenham Court Road Tube)
All post orders please to:—24-26, HAMPSTEAD RD., LONDON, N.W.1
EUSton 5533/4/5

LOOK ! ! ! A first-class SIGNAL GENERATOR that YOU can afford. The "Weyrad" type S.G.M.1. covers 100 kc/s to 70 mc/s. in 6 bands, on Fundamentals, with an accuracy better than ±2%. Switched Audio Mod.: 500 c/s. For use on A.C. Mains 100/250 v. 50 cycles. Fully illustrated leaflet available. Price ONLY £12/10/- plus 2/6 P. & P. H.P. available.

TRANSISTORS ! MULLARD TYPE O.C.71. Available ex stock at new list price of 24/- each, also O.C.70 at 21/- and O.C.72 at 30/-. BRIMAR T.S.I. 18/-. All post free.

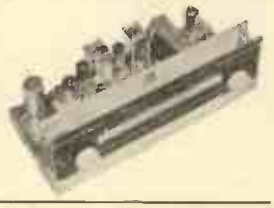
THE JASON FM TUNER

Based on the booklet by Data Publications Ltd., 2/- post free, including our individually priced Parts List. Highly sensitive free from drift. Incorporates 4 valves 6AM6 and 2 specially graded G.E.C. Crystals. The kit supplied includes drilled chassis with tuning condenser, scale calibrated in m/cs., and attractive bronze stove-enamelled front plate already mounted (illustrated). Front plate size 8in. × 5in. chassis 7in. × 4¼in. × 1¼in. Complete standard kit £6/15/- plus 2/6 P. & P. Fringe area kit £7/15/-, plus P. & P.

FM POWER PACK KIT. We can now supply complete kit for power pack suitable for the above F.M. tuner or any other similar type. Price for the complete kit is 37/6 only, or 52/6 for ready assembled unit. This pack is extremely small, incorporating valve rectifier type 6X4 and built on chassis size only 6×4×1¼in. Optional extra for power pack. Bulgin Octal Plug 2/3.

THE T.S.L. FM TUNER !

We can now supply this FM/VHF adaptor either in kit form or fully assembled, wired and tested. Our price for the ready-built unit, which incorporates its own power supply is £13/15/- only, tax paid, plus 5/- P. & P. or H.P. terms. Magic eye tuning indicator, just plug in, 19/- extra. Or the kit complete as specified £10/19/6 plus 3/6 P. & P. The booklet "FM TUNER CONSTRUCTION" (32 pages) with full technical data and point-to-point wiring diagrams together with our separately priced parts list, is available at 2/6 post free.



THE T.S.L. AM/FM CHASSIS! 1957 Model !
9-valve Superhet with F.M./VHF Band (4 wavebands). Push-pull output. Slow motion tuning drive. Full provision of Automatic Volume Control. Sockets provided for Aerial, Earth, Gram, Pick-up and Extension Speaker. Connections provided to Gram. Motor controlled by Chassis On/Off switch. The tone controls have been given an extra wide range to embrace all types of recordings. A.C. 200/250 volts, 50 cycles only. Leaflet available. CASH £27/6/-. Packing and carriage 7/6. H.P. terms available. Demonstrations at 18 Tottenham Court Road.

INTRODUCING THE NEW T.S.L. FM TUNER UNIT.
This compact unit with built-in power supplies has been designed by craftsmen to standards which will satisfy the most critical enthusiast. Brief specifications: Valve line-up: ECC85, 2-EF89, EABC80, 6X4 and EM80. Overall size: 10¼in. W. × 5¼in. H × 6¼in. D. Dial size 10¼in. × 5¼in. Attractive plastic dial in Black and Gold with easy-to-read calibration. Controls: Switch, OFF FM & GRAM. and tuning. Pre-set gain control at rear of chassis. Connections: Co-Axial output socket, 300 ohm aerial input socket and pick-up input socket on rear of chassis. Price £17/10/-, plus 5/- P. & P.

THE DULCI FM TUNER. Incorporates own power supply, suitable for use with any amplifier. Valve line-up. ECC85, two EF89, EABC80, 6X4 and EM80 indicator! Overall size: 9×6×5¼in. high. Pre-Budget price £16/16/-, plus 5/- P. & P. Illustrated leaflet available, also H.P. terms.

THE R.E.P. 1-VALVE RECEIVER. All-dry battery operation, for use with headphones The complete kit is available at 42/-, less batteries plus 2/- P. & P. or full instructions at 9d. post free.

COIL PACKS. Manufacturers' Surplus. Miniature size, only 2¼in. × 2¼in. × 1¼in. deep Iron-cored. For L., M. and S.W. with gram. position. Switch has 2in. spindle. Absolutely brand new, complete with circuit. Price only 7/6, plus 1/6 P. & P. A snip!

TELEVISION TURRET TUNERS 12 CHANNEL—"TELENG"

We have six types now available from stock, to cover Bands I and III—fully illustrated and descriptive leaflet available on request. Each unit is fully aligned and thoroughly tested before despatch. Valves employed are PCF80. PCC84 for AC/DC and ECF80 and ECC84 for A.C. Price complete £7/7/-, 2/6 P. & P. All channels available.

Type	Sound MC/s	Vision MC/s	Heater
TT34S	38.0	34.5	Series
TT34P	38.0	34.5	Parallel
TT16S	19.5	16.0	Series
TT16P	19.5	16.0	Parallel
TT13S	10.5	14.0	Series
TT13P	10.5	14.0	Parallel

We have a large selection of in-built converters for all areas from 92/6; also aerials low-loss co-axial cable at 9d. per yard Are you on our mailing list?

THE FAMOUS UNIVERTER—COMPARE THE PRICE

Handsome walnut cabinet. Suitable all areas. Contains own power supply. Simply connect to aerial. Four-valve circuit. Complete with all instructions. £6/19/6 plus 3/6 P. & P

PRE-SET TUNER UNIT
(Manufacturer's surplus.)

This is a two valve (TH41, VP41) superhet tuner unit covering, in original stage, two pre-set stations: Light and Home Service, with provision for adding a third station. Station selection is by means of an attractive illuminated Perspex knob. A small modification, the addition of a Germanium diode, is all that is required to enable this unit to be used in conjunction with any amplifier or tape recorder capable of supplying the necessary power: 200 v. D.C. at 20 ma. 4 volts at 2 amps. heaters. Alternatively built-in power supplies may be added. This is an exceptionally well made unit producing a "clean," good quality output. Dimensions of Tuner: 9in. L. × 3¼in. W. × 7¼in. H. Overall. Unit only 45/-, plus 2/6 P. & P. We can also supply all the components for built-in power pack with full modification details at 20/-.

DULCI AM/FM CHASSIS H4

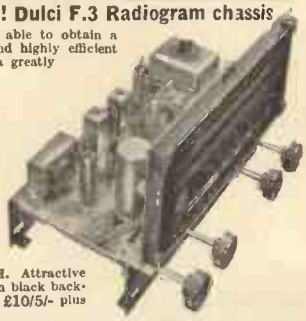
Illustrated leaflet available. L., M. and Short Waves plus F.M. This is a quality chassis 6 latest B.V.A. Mullard Valves, including magic eye. High Q inductances throughout, also Ferrite rods. Price is £24/6.6 cash—or H.P. terms.

SPECIAL PURCHASE ! MANUFACTURER'S SURPLUS

Owing to favourable purchase we can offer strictly limited quantity of these handsome chassis. AC/DC 200/250 v. for Medium and Long Waves, plus gram position. Incorporates own frame aerial. Valve line-up: U107, N108, DH107, W107 and X109. Overall chassis size 12×5¾×7¼in. high. Attractive bronze dial with gold and cream lettering. Dial size 11¼×4¼in. Scale length 7¼in. Logging scale provided. Price £7/19/6 only, tax paid, plus 3/6 P. & P. H.P. terms, £4 deposit plus four monthly payments of 22/-.

Splendid unrepeatable offer ! ! Dulci F.3 Radiogram chassis

We have been very fortunate in being able to obtain a limited quantity of this well known and highly efficient chassis which we are able to offer at a greatly reduced price.



Specification:
Three waveband: long 1,000-2,000 metres; medium 187-540 metres; short 16-50 metres. Valve line-up: X79, 6BA6 or W7A7, 6AT6 or DH77, EL84 or N709, 6X4 or U78.

Four controls, tone/on-off.

Volume wavechange.

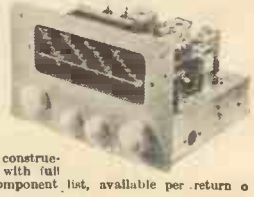
Tuning: output 4 watts matched to 3-5 ohms. Incorporates latest Ferrite Rod Aerial. Pick-up sockets and mains supply for Gram motor. Overall dimensions: 12in. L. × 7in. D. × 7¼in. H. Attractive dial with red, gold and green lettering on black background. Size 11¼in. × 4¼in. Price only £10/5/- plus 3/6 P. & P.

JUST RELEASED ! ! !
THE NEW R.C. TRANSISTOR/CRYSTAL RECEIVER KIT

This receiver, covering medium waveband, which can be assembled in about 1 hour, will give amazing volume and tonal quality when used in conjunction with a good aerial and earth. Incorporating PNP Transistor and Germanium Diode. For headphone reception.
Included with the kit of parts is a handsome plastic case in black and white, measuring 4½×2½×1¼in. This case accommodates the complete receiver, including battery.
PRICE OF COMPLETE KIT: 25/- plus 1/3 P. & P.
Lightweight high resistance headphones can be supplied separately at 15/- pair. If, however, the kit is purchased complete with headphones this will be supplied at a SPECIAL INCLUSIVE PRICE OF 37/6 plus 1/6 P. & P.
Optional extra. 100ft. coil single 7/36 coloured P.V.C. covered wire, suitable for both aerial and earth. 2/6 only.

TRANSISTORS ! ! ! Now available, manufacturer's surplus transistors. Suitable for use in Audio stages, etc., and for experimental purposes. P.N.P. type. Only 10/- each. post free. Blue spot type available for R.F. up to 1.6 Mc/s., 15/- each.

AM/FM KIT



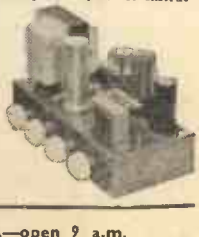
Introducing the JASON AM/FM KIT for medium waves and F.M.!
As illustrated this is a very high quality chassis incorporating 8 of the latest miniature valves, plus DM70 magic eye. Kits are available for chassis complete with output stage at £15/5/-. Also less output stage but with own built-in power pack at £13/19/6 only. These are high fidelity units and exceptional value at these prices which include all required components and full constructional details. Fully illustrated Data Booklet with full construction details, plus individually priced component list, available per return o post at 2/- post free. Both plus 3/6 P. & P.

DULCI H4T AM/FM TUNER

This unit has been designed for Quality Reproduction and built to the highest technical standards. Contains own power supplies. Brief specifications: four wavebands: VHF 87-101 mc/s. Short, 16-50 metres. Medium, 187-540 metres. Long, 1,000-2,000 metres. Intermediate Frequencies: 10.7 mc/s. and 471 Kc/s. Full A.G.C. on all A.M. Bands and amplitude limitation on F.M. Band. Three controls: ON/OFF, Volume, Tuning and Wavechange. Valve line-up: ECC85, ECH81, EF89, EABC80, EM80 and EZ80. Attractive dial in Black with Red, Green and Gold lettering, size 11¼in. × 5¼in. Chassis size (overall) 12in. W. × 7¼in. H. × 8¼in. D. A low impedance of 47K ohm output makes matching to amplifier non-critical. Weight 12lb. Price is £20/17/-, plus 5/- P. & P.

THE R.C.3/4 WATT AMPLIFIER KIT
Compare the advantages!

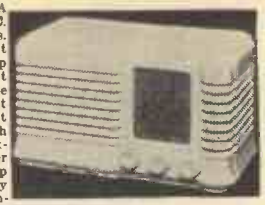
Treble, bass AND middle controls! For crystal or magnetic pick-up! A.C. Mains 200/250 v. Valve line-up: 6V6GT, 6SG7, metal 6X5GT. Negative feedback. Built on stove enamelled steel chassis, measuring only 8in. × 4in. × 1¼in. Four engraved cream knobs are included in the price of the complete kit with all necessary practical and theoretical diagrams at £4/5/- only, plus 2/6 packing and post or Instruction Book, fully illustrated for 1/-. Post free! This amplifier can be supplied assembled, tested, and ready for use at £5/5/- plus P. and P. Hearing is believing.



Our advantageous H.P. terms are available on any single item over £5. Let us have your enquiries.

Please add postage under £1, or Cash with order. C.O.D. charge extra—open 9 a.m. to 6 p.m. Monday to Friday. Sorry but we close 1 p.m. on Saturday

THE "ECONOMY FOUR" T.R.F. KIT. A three-valve plus metal rectifier receiver. A.C. mains 200/250 v. Medium and Long waves. We can supply all required components right down to the last nut and bolt. Valve line-up 6K7, 6J7 and 6V6. Chassis ready drilled. Cabinet size 12in. long by 6in. high by 5in. deep—Choice of ivory or brown Bakelite, or wooden walnut finish cabinet. Complete instruction booklet with practical and theoretical diagrams. Each component brand new and tested prior to packing. Our price £5/10/- complete—Remember this set is being demonstrated at our shop premises! We proudly claim that our fully illustrated instruction booklet is the most comprehensive available for this type of receiver—Booklet available at 1/6 post free. This is allowed if kit is purchased later. Plus 2/6 packing and carriage for complete kit.



THE "SUPERIOR FOUR" KIT. Our new four-valve receiver. A.C. mains. 200/250 v. M. and Long waves. As with our very successful "Economy Four" all required components as supplied. Valve line-up: 2 6SG7, 6 X5GT and 6 V6GT. Chassis ready drilled. Cabinet size 10½in. × 10in. wide. Maximum depth at base 5in. tapering to 3½in. at top. Sloping front. Very attractively finished in light walnut and peach. Each component brand new and tested prior to packing. Complete instruction booklet with practical and theoretical diagrams is provided. Booklet available at 1/6 post free. Our price for complete kit, £8/9/6! Please add 2/6 packing and carriage. If preferred, we can supply Cabinet Assembly only, comprising Cabinet and bracket wave-change switch, dial, pointer, drum pulleys, drive spindle, drive spring and knobs, at 45/-, plus 2/6 packing and carriage. N.B.—Our kits are even supplied with sufficient solder for the job.

N.B.—All our T.R.F. Kit circuits now include specially wound Denco "Max-Q" coils on polystyrene formers, improved performance! Price remains the same.

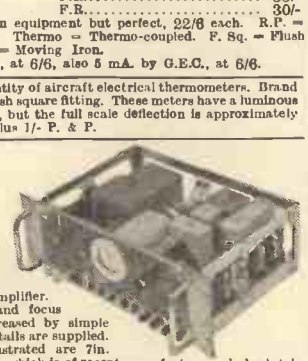
SURPLUS BARGAINS—METERS

F.S.D.	Size	Type	Fitting	Price
50 microamp	D.C. 5in.	M.C.	Rectangular	120/-
50 microamp	D.C. 4in.	M.C.	Rectangular	110/-
50 microamp	D.C. 3½in.	M.C.	F.R.	95/-
100 microamp	D.C. 2½in.	M.C.	F.R.	45/-
200 microamp	D.C. 2in.	M.C.	F.R. (Tropicalised)	30/-
200 microamp	D.C. 3½in.	M.C.	F.R.	65/-
500 microamp	D.C. 2in.	M.C.	F.R.	18/6
1 mA.	D.C. 2in.	M.C.	F.R.	17/6
1 mA.	D.C. 2in.	M.C	F. Sq.	22/6
1 mA.	D.C. 2in.	M.C.	F. Sq. (1954 manufacture by Elliott)	25/-
1 mA.	D.C. 2½in.	M.C.	Desk Type	30/-
50 mA.	D.C. 2in.	M.C.	F. Sq.	8/6
500 mA.	D.C. 2½in.	M.C.	F.R.	10/-
.5 amp.	R.F. 2in.	Thermo	F. Sq.	6/6
1 amp.	R.F. 2½in.	M.C.	F.R.	10/-
120-0-120 amp.	D.C. 2in.	M.C.	F. Sq. (shunt required)	15/-
150 amp.	A.C. 4in.	M.I.	R.P.	45/-
1 amp.	R.F. 2½in.	Thermo	R.P.	7/6
3 amp.	R.F. 2in.	Thermo	F. Sq.	6/-
20 amp.	D.C. 2in.	—	R.P. (with shunt)	10/6
30 amp.	D.C. 2½in.	M.I.	F.R.	12/6
15 volt	A.C. 2½in.	M.I.	F.R.	10/-
15-0-15 volt	D.C. 2½in.	M.C.	F.R.	17/6
300 volt	A.C. 2½in.	M.C.	F.R.	35/-
300 volt	A.C. 3½in.	M.I.	F.R.	30/-

SPECIAL U.S. 0-1 mA. 2½in. taken from equipment but perfect, 22/6 each. R.P. = Round Projection. M.C. = Moving Coil. Thermo = Thermo-coupled. F. Sq. = Flush Square. F.R = Flush Round. M.I. = Moving Iron.
METER RECTIFIERS. 1 mA. by G.E.C., at 6/6, also 5 mA. by G.E.C., at 6/6.

METER SPECIAL. We have a limited quantity of aircraft electrical thermometers. Brand new, by Weston, 2in. moving coil meter, flush square fitting. These meters have a luminous scale graduated 40-140 degrees centigrade, but the full scale deflection is approximately 150 microamps! Price 12/6 each only, plus 1/- P. & P.

SPECIAL PURCHASE!!
LIMITED QUANTITY ONLY.



A.A. PREDICTOR MK. I—OSCILLOSCOPE No. 11. This ex Govt. unit readily lends itself economically to conversion to oscilloscope for domestic use. For 115 v. or 230 v. 50 cycle A.C. mains—comprising 2½in. C.R.T. Type ACR10—4-EF91, EBC33, 6J5, 6X6GT, 5U2150A, and E.A.50. Continuously variable and stepped attentuator on Y amplifier. Internal X and Y shifts. Brightness and focus controls. Time base speeds can be increased by simple modification to cover 3 kc/s to 30 kc/s. Details are supplied. Overall measurements of chassis as illustrated are 7in. high, 12 in. deep and 19in. long. This unit, which is of recent manufacture and absolutely brand new, is offered at £12/10/- plus 15/- packing and carriage.) This is a fraction of original cost and a bargain not to be missed!

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EBF80	11/6	or39/6perset		UBC41	10/6
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ECC84	15/-	EL84	11/6	UY41	9/-
ECC85	10/-	EM80	9/-	6AQ5	8/6
ECF82	15/-	EY51	12/-	6AT6	8/-
ECH42	11/6	EY86	14/6	6AU6	9/6
ECH81	11/6	EZ40	8/6	6BA6	8/6
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EF41	10/6	PCF80	12/6	6BW6	8/6
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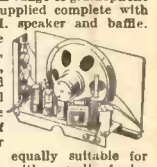

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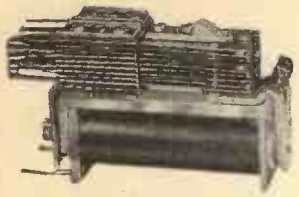

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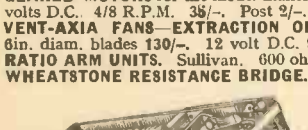

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6U6gt	5/11	ECL80	9/6	PY81	9/6
6L6g	8/6	ECC84	11/6	PY82	9/6
6Q7	8/6	ECC85	9/6	U25	11/6
6X5gt	7/6	ECC83	8/6	U404	10/6
7C5	8/–	ECH42	9/6	UAF42	10/6
7C6	8/–	ECH81	10/–	UB41	8/11
7S7	9/6	EF80	8/11	UBC41	9/6
7Y4	7/6	EF85	9/6	UBC42	10/6
10F1	10/6	EF41	10/6	UCH42	10/6
10F9	10/6	EF86	11/6	UY41	9/6
12J7	9/6	EL41	9/11	UL41	10/6
12K8	12/6	EL42	10/6	UF41	9/6
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Comprising the well-known BC625 and BC624A. Units complete with 17 valves types 2-832, 3-12A6, 3-12SG7, 3-9003, 9002, 6G6G, 12I5GT, 12AH7GT, 12C8, 6S87. The Complete unit is in very good condition having very useful parts including Relays, Transformers, Condensers, etc.
Less valves, £3/10/- carr. paid. With valves, £7/10/-, carr. paid.

TRANSISTOR PUSH-PULL AUDIO AMPLIFIER

(150 MILLIWATTS OUTPUT)

Build this Push-Pull Amplifier which is ideal for Crystal or Magnetic Pick-up Amplification, Baby Alarm, Microphone Amplifier, etc.
Powered by 6-volt Dry Battery lasting for months.
Complete Kit of Parts including 4 Transistors and all Components with Circuit (less speaker), £4/10/-.

TRANSISTORS

JUNCTION TYPE (Red-Spot) (P.N.P.)

These Red Spot Transistors are ideal for most circuits including "W.W." Pocket Transistor Receiver and Transistor Amplifier. All Transistors are British Manufactured and Guaranteed. Send for Circuits and Data.

10/- each

(Tested and complete with Data & Circuits)

N.B. These Transistors may be used in place of Mullard OC71 or similar Transistors.

R.F. Transistors (Blue-Spot) 1.6 Mc/s. 15/-

PRE-SELECTED SEVEN TRANSISTOR PUSH-PULL PORTABLE SUPERHET

Just switch to your favourite Station. No tuning, no aerial or earth. Pre-select 3 stations. Complete with all components and seven Transistors 7 x 4 Elliptical speaker. Teletron Superhet Coils and I.F.T.'s. Powered by 7½ v. dry battery which lasts for months. 150 Milliwatts output. All the above with Circuits, etc. £9/17/6. Carr. paid.

Or with Matched Mullard OC72's (200 Milliwatts Output) and 7 x 4 Elliptical High Resistance Speaker 30/- extra.

Suitable Plastic Cabinet easy to assemble 18/6.

Call and hear demonstration model working.

N.B.—The above is an improved version of the Transistor Six, giving greater output and selectivity. To those customers who purchased the Six Transistor version we offer the components and transistor required for modification for 17/6 post free.

"EAVESDROPPER"

THREE TRANSISTOR POCKET RADIO

(No Aerial or Earth required)

Pre-selected to receive the Light and Home Stations. Total cost, as specified in "Radio Contructor," including Transistors, Transformers, Coils, Condensers and Battery, etc., with circuit (less insert). **77/6** POST FREE

Acos Insert 15/6, Single Headphone 4/6 or Miniature Hearing Aid 24/-.

SPECIAL OFFER

Set of four Transistors including one R.F. Transistor ... 42/6
Set of six Transistors including one R.F. Transistor ... 60/-

TRANSISTOR SIGNAL TRACER

Complete Kit with 2 Transistors, Components, 'Phones with Circuit. 42/6.

TRANSISTOR SQUARE WAVE GENERATOR

Ideal for signal tracing.
Complete Kit with 2 Transistors Components and Circuit. 25/-.

62A INDICATOR UNIT

Containing VCR97 with Mu-Metal Screen 21 Valves: 12-EF50, 4-8P61, 3-EA50, 2-EB34. Plus Pots., Switches, H.V. Cond., Resistors, Muirhead S/M Dial. Double Deck Chassis and Crystal. BRAND NEW ORIGINAL CASES, 67/6. Carr. free.

1355 RECEIVER

Complete with 11 valves 8-SP61, 5U4G, VU120, VR92. As specified for inexpensive T.V. In absolute new condition, 27/6, carr. 5/-
R.F.24 10/-. R.F.25 12/6. R.F.26 25/-. Brand new with valves, carr. 2/6.

RECORD-CHANGERS

B.S.R. 3-speed—Plays Mixed Records £7/19/6
B.S.R. 4-speed—Plays Mixed Records £8/15/-
ALL BRAND NEW

MALLORY 6 v. VIBRATOR PACKS

Output 180 v. 40 m/a., 15/-. Brand new. P. & P. 2/-.

F.M. CONVERTER UNIT

88/100 Mc/s.

Containing 6 valves—2-6BA6, EB91, VR137, 2-EF54. Two I.F. stages and separate local oscillator, graduated Vernier tuning. Just plug into your radio and obtain good listening on F.M. Voltage required 250 v. 50 m/a. and 6.3 a. 2 amps.

£7 . 19 . 6

CATHODE RAY TUBES

VCR138A WITH SCREEN ..	£1	15	0
VCR139A	£1	15	0
VCR97. Guaranteed full T/V picture (carr. 2/-)	£2	0	0
VCR517C. Guaranteed full T/V picture	£1	15	0
MU-METAL SCREENS for VCR97 or 517		10	0
VCR97. Slight-cut-off. Carr. 2/-		15	0
3BP1. Brand new	£1	10	0

CRYSTAL MICROPHONE INSERTS

Ideal for Tape Recording, Gramophone Amplifier, etc. Very sensitive. Guaranteed and Tested, 5/-.

MINIATURE I.F. STRIP TYPE "373" 9-72 MEG.

Brand new miniature I.F. Strip size 10½in. x 2½in. x 3in. high. Valve line-up 2-EF92, 3-EF91 and EB91. With circuit.
With valves, 45/- (less valves 8/- post free).
This I.F. Strip is part of above equipment.

INDICATOR UNIT TYPE 182A

Unit contains VCR517 Cathode Ray 6in. tube, complete with Mu-Metal screen, 3 EF50, 4SP61 and 1 5U4G valves, 9 wire-wound volume controls and quantity of resistors and condensers. Offered BRAND NEW (less relay) at 67/6. Plus 7/6 carr. "Radio-Constructor" scope circuit included.

DEMOBBED VALVES MANUAL 2/6

Giving equivalents of British and American Service and Cross Reference of Commercial Types with an Appendix of B.V.A. Equivalents and Comprehensive Price List. We have still some Valves left at very old Budget Rates (33⅓%) which are actually sold at the old price. (1951)

THE NEW '2,000' AUTOMATIC BLOW TORCH

Burns methylated spirit. Completely Automatic and safe for all kinds of tin and silver soldering, glass bending, etc. 2,000 deg. Fahrenheit. Post free only 14/7

Great Britain's Valve Mail-Order House

CBL1, DAC32, DF9, DF92, DH77, DK92, DL82, DL93, EB41, ECC31, ECC81, ECC82, EF8, EF36, EF54, EK32, EL2, EL32, EM4, EM34, FC13, FC13C, H63, HD24, HL13C, HLDD1320, HP210, HP2110, KBC32, KF35, KL35, KT71, KT101, KTZ63, L63, LL4, MH4, MSP4, MU14, N17, N18, N329, N339, OZ4, PA1, Pen 428, PL82, PM1A, PM2A, PM22A, QP21, QP22B, QP230, R1, S130, SP2, SP13, SP42, S8210, U33, D149, U329, UB41, UR3C, UU7, VMS4, VP4, VP13A, VP13K, VP23, VP4, W101M, W145, W148, WD142, X22, X101M, X142, X145, ZD152.

1C1, 1A5, 1D6, 1LN5, 1S4, 2D4A, 3Q5, 5Z3, 6A6, 6AM5, 6AM6, 6AT6, 6B7, 6B8, 6BW6, 6C6, 6C8, 6C9, 6F8, 6H6, 6J7, 6L7, 6M1, 6N7, 6R7, 6SA7, 6SG7, 6U5, 6X4, 7A2, 7B6, 7B7, 7C5, 7C6, 7H7, 7Y4, 9D8, 10C2, 10P13, 12BH7, 12C8, 12SL7, 16A5, 17Z3, 20D1, 25Y5, 25Z5, 41MH, 43, 50Y6, 67PT, 240QP.

LIMITED QUANTITY SALE 7/6 post 1/-

RADIO **BULLS** VALVES
246 HIGH ST., HARLESDEN, N.W.10

ELECTRIC CLIPPERS

Easy instructions in illustrated 12-page booklet with every set. Packed in luxury presentation case with cleaning brush, oil for lubrication and two special detachable combs for graduating fineness of cut. On/off switch, 6ft. of flex, and two-pin plug. A.C. only 200/250 volts. Fully guaranteed for twelve months. £5/5/- or only 2/- down and seven monthly payments of 16/9.

AMERICAN type, British-made **PAINT SPRAYER**

New model for up & down spraying of all painting jobs in & out-doors. 3/- down & 6 m'ly of 9/6 or Cash Price Reduction Offer at 67/6.

3/- *Full Guarantee*

TALK on your Own Radio **-SING** **RADIOMICROPHONE**

Ex-W.D. BARGAIN

Ideal for parties, Socials, Functions, Meetings, Dances, etc. Self-energised, on/off switch fitted, table stand and hand grip. 3ft. cable. Limited quantity only. Two for 26/-. Post free.

12/6 Post 2/-.

ELECTRIC PAINT STRIPPERS

Simple and safe—strips paint clean without scorching of woodwork and with the minimum cleaning down. Sturdy for trouble-free service and backed by a twelve-month guarantee. A.C. or D.C. 200/250v. Special voltages to order. Prices 39/6, or 42/6 with built-in switch.

Or 5/6 down and 8 monthly of 5/6

CONVERT your old TV Do it yourself. It's so easy. Save money and get B.B.C. & I.T.A. Commercial at the flick of a switch. You simply place our Silver TV Converter on or near your TV set. No alterations to your set—just connect with A.C. mains and aerial. Packed complete with easy instructions. Only 21/- down and 6 monthly of 21/- or cash £6/6/-.

Chassis Cutters with Keys

The easiest and quickest way of cutting holes in sheet metal. The cutter consists of three parts: a die, a punch and an Allen screw. The operation is quite simple. Prices incl. key: Size ⅛in., 13/9; ¼in., ⅜in., 14/9; ½in., ⅝in., ¾in., 17/6; ⅞in., 1in., 1⅛in., 19/6; 1¼in., 22/-; 2 3/32in., 35/9; 2½in., 40/9; 1in. sq. hole 27/-. Post 1/-.

All prices are with keys

SERVICE SHEETS

The one you require enclosed if available in a dozen assorted of our best choice. 10/6

PIFCO

All-in-one Radiometer A.C./D.C.

- ★ Circuit Test.
- ★ L.T. & H.T. Tests.
- ★ mA. Test.
- ★ Valve Test.

Continuity and Resistance Tests. Complete with Test Leads.

Post 1/-. 32/6

5mm. & 7.5mm. Pea Bulbs

CAP. L.E.S. to British Standard 98/E5. Diameter 5mm. Length 8mm. BALLOONS. Tubular 5mm. Spherical 7.5mm. OVERALL LENGTH. Tubular 15mm. ± 1mm. Spherical 16mm. ± 1mm. RATINGS. Voltages up to 24 volts.

VITALITY BULBS

Subminiature and all other indicator types.

Vitality Bulbs Ltd., Neville Place, London, N.22

Phone : BOWes Park 0016

BELCLERE TRANSFORMERS

Actual Size in Screening Can

$\frac{9}{16}" \times \frac{1}{2}" \times \frac{25}{64}"$

Pictured above is a type F transformer (the smallest in this range) for use in transistor circuits.

We are specialists in the manufacture of transformers and inductors to customers' requirements. Please write for illustrated leaflets.

BELCLERE TRANSFORMERS, 117 HIGH STREET, OXFORD

Telephone: 3432 ● Cables: Belclere, Oxford.

OSMOR Coils for COLLARO

(Officially Recommended)

Free! Send 10d. in stamps for circuits, practical drawings on band III Converters, T.R.F. & S'het tuners and receivers. Circuit of switch-tuned (frequency controlled) F.M. Tuner. Components and information on most published circuits in

WIRELESS WORLD, PRACTICAL WIRELESS RADIO CONSTRUCTOR.

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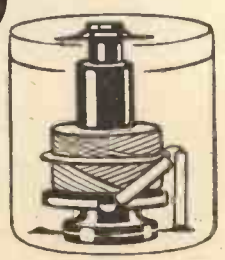

Bias Osc. Coil Type QT9 7/6

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Dept. (W.W.8.) 418 BRIGHTON RD., SOUTH CROYDON, SURREY. *Telephone: CROydon 5148/9*

OSMOR SWITCH-TUNED F.C. F.M. NOW READY

C.R.T. ISOLATION TRANSFORMERS

For Cathoae Ray Tubes having Heater/Cathode short circuit for C.R. Tubes with falling emission.
Type A. Low leakage windings. Ratio 1:1.25 giving a 25% boost on Secondary.

2 volt	10/6 each	With Tag
4 volt	10/6 each	Panel and
6.3 volt	10/6 each	Solder Tags
10.8 volt	10/6 each	
13.3 volt	10/6 each	

Ditto with mains primaries 12/6 each.
Type B. Mains input 220/240 volts. Low Capacity. Multi Output 2, 4, 6.3, 7.3, 10 and 13 volts. Input has two taps which increase output volts by 25% and 50% respectively. This transformer is suitable for all Cathode Ray Tubes. With Tag Panel 21/- each.
Type C. Low capacity wound transformer for use with 2 volt Tubes with falling emission. Input 220/240 volts. Output 2-2½-2½-2¾ volts at 2 amps. With Tag Panel 17/6 each.
All Isolation Transformers are individually boxed, labelled and clearly marked with relevant data.
NOTE:—It is essential to use mains primary types with T.V. receivers having series connected heaters.

RESISTORS. All values. 10 ohms to 10 meg., ½ w., 4d.; ½ w., 6d.; 1 w., 8d.; 2 w., 1/-.
HIGH STABILITY. ½ w. 1%, 2/-. All preferred values 100 ohms to 10 meg.
WIRE-WOUND RESISTORS
5 watt, 10 watt, 15 watt } 25 ohms—10,000 ohms ..... { 1/3, 1/6, 2/-
15,000 ohms—50,000 ohms, 5 w., 1/9; 10 w..... 2/3
WIRE-WOUND POTS. 3 WATT LAB. COLVERN, ETC.
Pre-set Min. T.V. Type Knurled Slotted Knob. All values 25 ohms to 30 K. 3/- ea. 50 K., 4/-. Ditto Carbon Track 50 K. to 2 Meg., 3/-.
Standard size Pots., 2½in. Spindle High Grade. All Values, 100 ohms to 50 K., 5/6; 100 K., 6/6.
W/W EXT. SPEAKER CONTROL 10Ω, 3/-.
O/P TRANSFORMERS. Heavy Duty 50 mA., 4/6. Multi-ratio push pull, 6/6. Tapped small pentode, 3/9. Hygrade Push Pull 7 watts, 15/6.
L.F. CHOKES 15/10 H. 60/65 mA., 5/-; 25/20 H. 100/120 mA., 11/6; 20/15 H., 120/150 mA., 12/6; 5 H. 250 mA., 15/-.
MAINS TRANS. 350-0-350, 80 mA., 6.3 v. tapped 4 v. 4 a. 5 v. tapped 4 v. 2 a., ditto 250-0-250 80 mA., etc., 21/-.

I.F. TRANSFORMERS 7/6 pair

465 Kc/s Slug tuning Miniature Can, 2½ × 1½in. × ¾in. High Q and good band width. By Pye Radio. Data sheet supplied.

Wearite M800 IF Transformers 465 kc/s 12/6 pair.

HEATER TRANS. Tapped 200/250 v. 6.3 v. 1½ amp., 7/6
COPPER PLATED AERIAL RODS. ¼×12in. push fitting, 3/- oz. Post 1/-.
ALADDIN FORMERS and cores. ½in. 8d.; ¾in., 10d. ⅜in. FORMERS 5937/8 and Cans TV1/2. ½in. sq. × 2½in. and ¾in. sq. × 1¾in., 2/- complete with cores.
SLOW MOTION DRIVES. Epicyclic ratio 6:1, 2/3.
TYANA. Midget Soldering Iron. 200/220 v. or 230/250 v. 16/9. SOLON MIDGET IRON. 25 w., 24/-.
MIKE TRANS. Ratio 50:1. 3/9 ea., new and boxed.
MAINS DROPPERS. 3×1½in. Three Adj. Sliders, .3 amp. 750 ohms, 4/3. .2 amp., 1,000 ohms, 4/3.
LINE CORD. .3 amp., 60 ohms, per foot, .2 amp., 100 ohms, per foot. 2 way, 6d. per foot, 3 way, 7d. per foot.

CRYSTAL MIKE INSERT by Acos

Precision engineered. Size only 1⅞×3/16in. Bargain. Price 6/6. No transformer required.

LOUDSPEAKERS P.M. 3 OHM. 2½in. square 17/6.
5in. R.A. 17/6. 7in. × 4in. Goodmans 21/-.
3½in. Square Elac., 21/-. 8in. Elac, 22/6.
6½in. Goodmans, 18/6. 10in. R.A. 30/-.
T&L TWEETER L8H75, 8/6. 12in. Plessey 30/-.
8in. M.E. 2.5 k. field tapped O.P. transformer, 24/6.
CRYSTAL DIODES. G.E.C., 2/-. GEX34, 4/-.
CRYSTAL SET CONSTRUCTION. Kit 12/6.
H.R. HEADPHONES. 4,000 ohms, brand new, 16/6 pair.
SWITCH CLEANER Fluid, squirt spout, 4/3 tin.
TWIN GANG CONDENSERS. 365 pf. midget, 1½in. × 1½in. × 1¾in., 10/-. .0005 Standard with trimmers, 9/-; less trimmers, 8/-; soiled, 2/6; 3-gang 500 pf., 7/6.

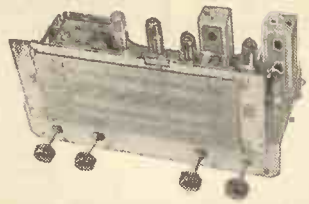
SUPERHET COIL PACK 27/6

Miniature size 2½ × 2½ × 1¾in. High Q dust cored coils. SHORT, MED., LONG. GRAM switching with connection diagram and circuit.

VALVE HOLDERS. Pax int. Oct., 4d. EF50, EA50, 6d. B12A, CRT, 1/3. Eng. and Amer. 4, 5, 6, 7 and 9 pin, 1/-. MOULDED Mazda and Int. Oct., 6d. B7G, B8A, B8G, B9A, 9d., B7G with can, 1/6, VCR97, 2/6. B9A with can, 2/6.
CERAMIC, EF50, B7G, Int. Oct., 1/-. B7G with can, 1/9.
SPEAKER FRET. Gold Cloth 18in. × 25in., 5/-. 25in. × 36in., 10/-. Expanded metal, Silver 15½ × 9¼in., 2/- each. 14¼in. × 12in., 3/- each.
WAVECHANGE SWITCHES.

2 p. 2-way 3 p. 2-way, short spindle	2/6
5 p. 4-way 2 wafer, long spindle	6/6
2 p. 6-way, 4 p. 2-way, 4 p. 3-way, long spindle	3/6
3 p. 4-way, 1 p., 12-way, long spindle	3/6
TOGGLE SWITCHES. S.P., 2/-. D.P., 3/6. D.P.D.T.	4/-
NUTS, BOLTS, 12 of each, 2, 4 or 6BA	1/-

KNOBS, GOLD ENGRAVED. Walnut or Ivory. 1½in. diam., 1/6 each. "Focus," "Contrast," "Brilliance," "Brilliance—On/Off," "On-Off," "Volume," "Volt-On-Off," "Tone," "Tuning," "Treble," "Bass," "Wavechange," "Radio Gram," "S.M.L. Gram," "Record-Play," "Brightness," ditto, not engraved, 1/-.



1957 RADIOGRAM CHASSIS

THREE WAVEBANDS: S.W. 16 m.—50 m. M.W. 200 m.—550 m. L.W. 800 m.—2,000 m.
FIVE VALVES: LATEST MULLARD ECH42, EF41, EBC41, EL41, ELZ40
12 month Guarantee. A.C. 200/250 v. 4-way switch. Short-Medium-Long-Gram. A.V.C. and Negative feedback. 4.2 watts. Chassis 13½in. × 5½in. × 2½in. Glass Dial 10 × 4½in., horizontal or vertical available. 2 Pilot Lamps. Four Knobs, Walnut or Ivory, aligned and calibrated. Chassis isolated from mains.
T.S.L. Tweeter supplied free.

BRAND NEW £10.10.0 Carr. 4/6.

TERMS: Deposit £5/5/- and 6 monthly payments of £1.

AM/FM RADIOGRAM CHASSIS

Measurements 13in. × 6in. × 7in. high. Dial cut-out required only 10½in. × 2½in. 5 valve plus metal rect., gram. socket, piano key wavechange, tone control, med., long and V.H.F. wavebands. Valve line-up: ECC85, ECH81, EF89, EABC80, EL41. For A.C. mains 100-250 v.

PRICE **£16.19.6** Carriage 10/6.

MATCHED SPEAKERS FOR ABOVE CHASSIS 8in., 19/6; 10in., 25/-; 12in., 30/-.

Collaro Autochanger RC531 for 78 R.P.M. 10in. and 12in. Records. Brand new in maker's boxes! High impedance, light-weight pickup with sapphire needle, will match any amplifier or radio. Less than half price. Terms: deposit £2-15-0 and 6 monthly payments of 10/-. **5 GNS.** Post free. No C.O.D.

FAMOUS MANUFACTURER'S

4-SPEED AUTOMATIC RECORD CHANGERS

1957 MODELS

Brand new and fully guaranteed 12 months.

NOT JOB LINE REJECT STOCK

Designed to play 16, 33, 45, 78 r.p.m., Records 7in., 10in., 12in. Lightweight Xtal pick-up, turnover head, two separate sapphire styli, for Standard and L.P. each plays 2,000 records. Voltage 200/250 A.C.

OUR PRICE **£8.15.0** each. Post free.

Terms: Deposit £5 and 5 monthly payments of £1. Space required 14in. × 12½in. 5in. above and 3in. below.

TRANSISTORS

JUNCTION TYPE (Red-Spot) (P.N.P.)

Suitable for use in Amplifiers, Signal Tracers, Local Station Receivers, Radio Control, Oscillators, Transistor Voltmeters, Baby Alarms, Microphone Pre-Amplifiers, etc. A.F. 800 Kc/s

10/- EACH

BRAND NEW

These Transistors may be used in place of Mullard OC71.

B.S.R. MONARCH. 3-speed Motor and Turntable with selecting switch for 33, 45 and 78 r.p.m. records 100-120 v. and 200-250 v. A.C. 50 c.p.s. Also B.S.R. MONARCH Lightweight Pick-up with Acos Xtal turnover head, separate Sapphire stylus for L.P. and standard records. SPECIAL OFFER, THE TWO £4/12/6. post 2/6. 14" x 12½" Cut Out board 6/-.

Teletron Band III Converter

London, Midland and Northern for all T.V. Makes. T.R.F. or Superhet

Ready wound coils, two EF80 valves, all components, punched chassis, circuit diagram, wiring plans. COMPLETE KIT for mains operation. 200-250 v. A.C. £3/10/-.
AS ABOVE less POWER PACK. Requires 200 v. 20 mA. H.T. 6.3 v. 0.6 a. L.T. £2/5/-.

ALLDRY UNIT POWER PACK. Replaces Battery B114, etc., 69 v. plus 1½ v. Size 4¼in. × 3¼in. × 1¾in. 4-pin Socket. Same as battery. Only 1/- a year to run on A.C. 200-250 v. FAMOUS MAKE. LIST PRICE 65/-. OUR PRICE 39/6. Ready for use

T.V. PRE-AMP. (McMICHAEL)
Will amplify output of your Band 3 Converter. Tunable Channels 1 to 5. Midget size. High gain fringe model. B.V.A. Valve. Full instructions supplied. READY FOR USE. (H.T. 200V., L.T. 6.3V., .3 amp. required). PRICE 25/- each. BRAND NEW. SPECIAL MAINS POWER PACK for above, 25/- extra.

Volume Controls

Midget size
Long spindles. Guaranteed 1 year. All values 10,000 ohms to 2 Meg.
No. Sw. S.P.Sw. D.P.Sw.
3/- 4/- 4/9
Lin or Log Tracks

80 ohm CABLE Coaxial

Semi-air spaced Polythene insulated ¼in. dia. Stranded core. Ideal Band III. Losses cut 50%....9d. yd.
STANDARD ¼in. Coaxial....8d. yd.

COAXIAL PLUGS 1/- DOUBLE SOCKET 1/3
SOCKETS 1/- OUTLET BOXES 4/6
BALANCED TWIN FEEDER per yd., 6d. 80Ω or 300Ω. TWIN SCREENED BALANCED FEEDER 1/- yd.. 80 ohms. TRIMMERS, Ceramic, 30, 50, 70 pf., 9d. 100 pf., 150 pf., 1/3. 250 pf., 1/6. 600 pf., 750 pf., 1/9.

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled, with 4 sides, riveted corners and lattice fixing holes, with 2½in. sides. 7×4in., 4/6; 9×6in. 5/9; 11×7in., 6/9; 13×9in., 8/6; 14×11in., 10/6; 15×14in., 12/6 and 18×16×3in., 16/6.

CHROMIUM PEN TORCHES with battery and bulb, 2/6.
BLACK CRACKLE PAINT. Air drying, 3/- tin.
P.V.C. CONN. WIRE, 10 colours, single or stranded, 2d. yd.
5in. RADIO SCREWDRIVERS, 4½d. each.
NEON MAINS TESTER SCREWDRIVERS, 5/6.
MULTICORE SOLDER 60/40, 18 s.w.g., 3d., 16 s.w.g., 4d. yd.

PURETONE RECORDING TAPE. 12/6

1,200ft. on standard fitting 7in. Plastic reels Brand new, boxed, 12/6.
Spare Spools 5in. metal, 1/6. 7in. Plastic, 4/3.

FERROVOICE PLASTIC TAPE 25/-

First Quality. Highly Recommended. Brand new. 1200ft. on 7in. plastic Reels. 25/-.

SENTERCEL RECTIFIERS. E.H.T. TYPE FLY-BACK VOLTAGES. K3/25 2 kV., 5/-; K3/40 3.2 kV., 7/-; K3/45, 3.6 kV., 7/6; K3/50 v. 4 kV., 8/-; K3/100 8 Kv., 14/6.
MAINS TYPE, RM1, 125 v.; 60 mA, 5/-; RM2, 100 mA., 6/-; RM3, 120 mA., 8/-; RM4, 250 v. 275 mA., 16/-.
MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 ma., 8/6; 250 v. 85 ma., 9/6.
COILS. Wearite, "P" type, 3/- each. Osmor Midget "Q" type adj. dust core, 4/- each. All ranges.
TELETRON. L. & Med., T.R.F., A/HF., 7/- pair.
H.F. Chokes RFC4 9/6 each.
M.W. XTAL COIL HAX., 3/-, L.W. 3/6.

JASON F.M. TUNER COIL SET. 22/6. H.F. coil, aerial coil, Oscillator coil, two I.F. Transformers 10.7 Mc/s., Detector transformer and heater choke. Circuit and component book using four 6AM6, 2/- J.B. Chassis and Dial, 19/6. Complete Kit, £5/18/6. With Jason superior calibrated dial, £6/15/-.

CONDENSERS. New stock. .001 mfd. 7 kV. T.C.C., 5/6. Ditto 20 kV., 9/6; 100 pf. to 500 pf. Micas, 6d.: Tubular 500 v. .001 to .01 mfd., 9d.; .05, .1, 1/-; .25, 1/6; .5, 1/9; 1/350 v., 9d.; .1/600 v., 1/3; .1 mfd. 2,000 v., 4/-.
CERAMIC CONDS. 500 v., .3 pf. to .01 mfd., 10d.
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6AT6		6H6M	EF36	EL41
6K8				EL84
6SL7	7/6	7/6	7/6	EZ40
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★ Tunable over Band III range
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Fully guaranteed against faulty workmanship or materials (other than valves) for 12 months.
The unit uses B.V.A. valves. Guaranteed for 90 days.

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Self-screening iron dust cupped coils with adjustable iron dust cores.

Coil No.	Waveband (Metres)	Stage	Price Each
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Small Mains Transformer suitable for Television Converters, etc.
Specification:
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Secondary: 1 : 250 v. 40 mA.
Secondary: 2 : 6.3 v. 1.5 A. 15/-

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HF812 8in. Unit Combined speech coil, 3-, 7.5- and 15-ohm, 5 watts	83/6	24/-
HF1012 10in. Unit Combined speech coil, 3-, 7.5- and 15-ohm, 10 watts	99/6	28/9
HF1214 12in. Unit 25-14,000 cps., 15 watts	195/6	—

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25 watts.
Weight 3½ oz. (excluding flex). Length 9in.
Now available in a wide range of voltages as under:

Irons	Voltage	List No.	Price
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Instrument	50	620	26/-
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bit	200/220	624	24/-
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65-watt Type Oval Bit			29/-
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Chassis Mounting Gang Condenser with split-stators, ceramic insulation. Cadmium plated chassis. Silver plated brass rotor and stator. Rotor earthed to frame. Capacities available each half: 3/10 pf., 3.8-27 pf., 4-35 pf. or 4.43 pf. Price 10/9 complete.

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MAINS TRANSFORMERS

3-way Mounting Type

MT1
Primary: 200-220-240 v.
Secondaries: 250-0-250 v. 80 M/A, 0-6.3 v. 4 amp., 0-4 v. 2 amp., both tapped at 4 v., each 19/6

MT2
Primary 200-220-240 v.
Secondaries. 350-0-350 v. 80 M/A, 0-6.3 v. 4 amp., 0-5 v. 2 amp., both tapped at 4 v., each 19/6

MT3
Primary: 200-220-240 v.
Secondary: 30 v. 2 amp.
Taps at 3 v., 4 v., 6 v., 8 v., 9 v., 10 v., 15 v., 18 v., 20 v., 24 v., each 19/6

2/- Packing and Post on above transformers.

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Type "88" is a standard thickness base tape giving maximum durability for general-purpose use.

"88" GENERAL PURPOSE

Type No.	Title	Size dia.	Length	Price
88/3	Message	3in.	175ft.	7/6
88/6	Junior	5in.	600ft.	21/-
89/9	Continental	5½in.	850ft.	28/-
88/12	Standard	7in.	1,200ft.	35/-

Type "99" is a specially developed thin base tape giving an increase of 50 per cent. recording time for Long Play purposes.

"99" LONG PLAYING

Type No.	Title	Size dia.	Length	Price
99/3	Message	3in.	250ft.	9/6
99/9	Junior	5in.	850ft.	28/-
99/12	Continental	5½in.	1,200ft.	35/-
99/18	Standard	7in.	1,800ft.	50/-

EM.1 RANGE OF EMPTY SPOOLS, IN CARTONS

AP93	3in. Message spool	3/-
AP85	5in. Junior spool	4/6
AP89	5½in. Continental spool	4/6
AP87	7in. Standard spool	5/-

EM.1 JOINTING AND EDITING ACCESSORIES

AP37 Gummed jointing tape, per reel 6/6
AP38 Editing and marker tape: AP38/1 white; AP38/2 red; AP38/3 yellow; AP38/4 blue; AP38/5 orange; AP38/6 green, all at per reel 4/6
AP46 Tape jointing block and cutter for the accurate alignment and splicing of tape 17/6

SCOTCH BOY TYPE 111 STANDARD RECORDING TAPE

600ft. on 5in. plastic spool, per reel 21/-
1,200ft. on 7in. plastic spool, per reel 35/-
Spare spools: 5in. diameter 3/6
7in. diameter 4/3

SCOTCH BOY TYPE 150-9 "EXTRA PLAY" RECORDING

900ft. on 5in. diameter spool, per reel 32/-
1,200ft. on 7in. diameter spool, per reel 54/-

LOUDSPEAKERS

ALL P.M. TYPES LESS TRANSFORMER

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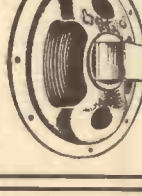

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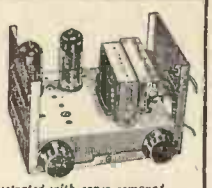

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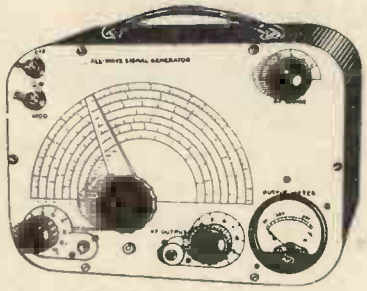

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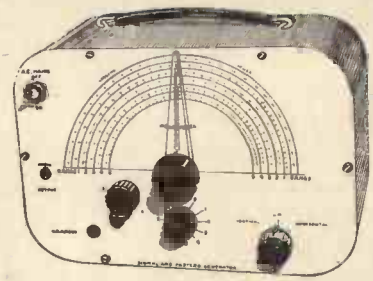

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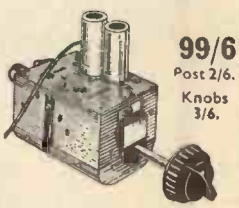

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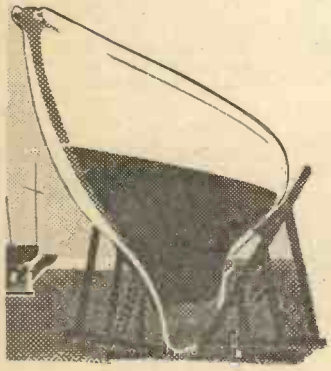

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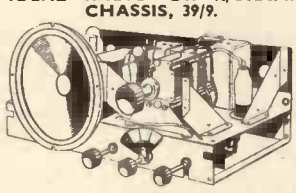

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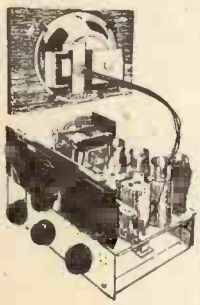

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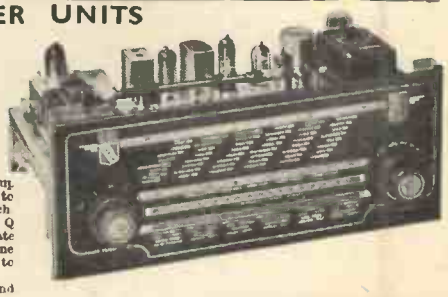

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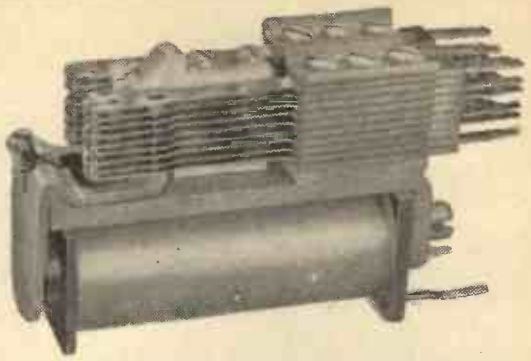

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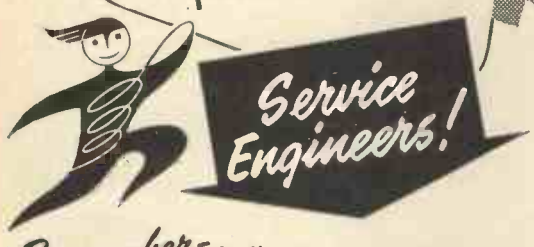

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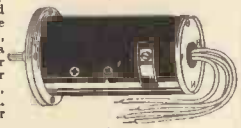

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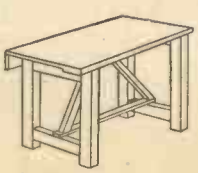

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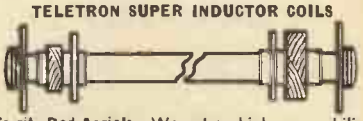
You can build these kits, as did M. E. of Wellingborough, who says:—
"I am getting very good results from it, as good as a professionally made tape recorder."
Send stamp for full particulars to:—

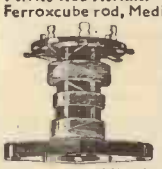
W. S. ASPDEN,
10, MARKET STREET, WESHAM,
KIRKHAM, LANCS.

PURCHASE, HIRE OR HIRE-PURCHASE
VORTEXION Tape Recorders and P.A. Equipment, etc.
also Recordings—Tape to Tape/Disc Service
GRIFFITHS HANSEN (Recordings) LTD.
32-33, GOSFIELD STREET, LONDON, W.1
Phones: MUSeum 2771/0642

TELETRON SUPER INDUCTOR COILS

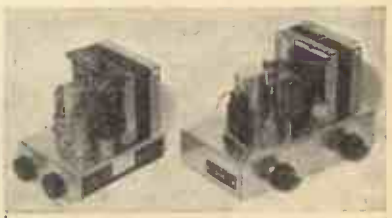


Ferrite Rod Aerials. Wound on high permeability Ferroxcube rod, Medium wave 8/9, Dual wave 12/9.



Type HAX. Selective crystal diode coil for tape and quality amplifiers, MW 3/-, LW 3/6. Dual wave TRF Coils, matched pairs (as illustrated) 7/- pair. Type S.S.O. Supersonic Tape Osc. coil, provides 6.3 v. 3 a. RF for pre-amp heater. Eliminates induced 50 c/s hum, 40/100 kc, 15/- ea. Transistor coils, etc. Available from leading stockists. Stamp for complete data and circuits.

THE TELETRON CO. LTD.,
266, Nightingale Rd., London, N.9. How. 2527



3-VALVE QUALITY AMPLIFIERS
Suit modern crystal P.U.s; for 200-250 v. A.C.; neg. feedback, volume and tone controls; new Components and PLAYING TESTED.
B7g £4/7/6, INT. OCTAL £4/2/6, B9A £4/12/6. Carr. 3/6 all types.
E.K.E. 47, Arksey Lane, Bentley, Doncaster.

COMPUTER MAINTENANCE

British Insulated Callender's Cables Ltd. invite applications for the following posts with their Computer Department at Prescot:—

(a) **SPECIAL SERVICE ENGINEER** to undertake a Specialist Maintenance and Advisory Service for the department. Applicants should preferably hold an Honours Degree in Physics or Electrical Engineering, and have experience of Electronic Valve applications and Pulse Techniques.

The successful candidate would be required to undergo a period of training on Computers in the London Area, and subsequently would be attached to the staff of the Company's Telecommunications Laboratory, where opportunities would exist for participation in the development of Electronic Test Instruments.

(b) **MAINTENANCE TECHNICIAN**
A vacancy also exists for a Maintenance Technician for the Computer. Candidates should have experience of servicing Radar or similar equipment, and preferably be qualified to O.N.C. standard. A period of training in the London Area would be arranged for the successful candidate.

Applications should be submitted in writing giving details of age, qualifications and experience and quoting P/5/57 to the **Staff Officer, British Insulated Callender's Cables Ltd., Prescot, Lancs.**

PHILIPS ELECTRICAL LTD., require a **CORRESPONDENCE CLERK** for their Service Department at Waddon, Surrey. The work involves the ability to dictate good English and the interpretation of technical points so that they can be understood by the layman. Applicants should have experience in dealing with business correspondence and also have a basic technical knowledge of the circuits used in radio and television receivers.

Staff appointment, 5-day 39½ hour week, canteen. Superannuation scheme.

Write giving details of age, education and experience to the Personnel Officer, Beddington Farm Road, Croydon, quoting reference GDS.

CABINETS

Many and varied designs in Bureau, Piano, Console and Table models.

The Contina Cabinet

The exterior is finished in high polished dark walnut veneer and panelling picked out with gold metallic strip work. The interior also is complete in its high standard of finish and is veneered in light mahogany. Size: 3ft. 1½in. long, 1ft. 3in. deep, 2ft. 9½in. high, including legs which are 10in. from the floor. Motor board 12½in. × 17in. Dial aperture 17½ in. × 9½ in. Will accommodate an 8in. speaker. Also full storage space is provided. The half length doors are slid on metal runners and are provided with gold inset finger plates. An excellent cabinet for the modern home. Boards completely uncut.

Send for our Monthly Bulletin.

Send also for our detailed wholesale list for cabinets, wire chassis FM/AM. Complete TVs. Radio Aerials, convertors & sundry Electrical components. E.C. shavers, etc.

Trade only supplied.

V.E.S. WHOLESALE SERVICES Ltd.

Dept. (W.W.), 11, Gunnersbury Lane, Acton, W.3 *Tel.: ACOrn 5027*

SAMSON'S SURPLUS STORES

CONSTANT VOLTAGE TRANSFORMERS by Advance Components Ltd. Input 190-260 v. Output 230 v. 150 watts. Supplied new at a fraction of maker's price. **£6/10/-**, carr. 7/6.

HEAVY DUTY VARIAC TRANSFORMERS by Zenith Electric Co. Type 50B, input 230 v. Output 0-270 v. 20 amps. Complete with control handle and dial plate. **£37/10/-**, ex warehouse.

HOOVER BLOWER MOTORS. A.C. 220-230 v. Twin V shape. outlets. Fitted with Vokes Ltd. filters. **£6/10/-**, carr. 7/6.

MAGSLIP TRANSMITTERS. 3in. MK2, **12/6**, postage 2/6.

MAGSLIP RECEIVERS 2in. MK2 **7/6**, postage 2/-.

METRO-VICKERS MASTER VOLTMETERS. M.I.O.-20 v. A.C. 6in. mirrored scale **25/-**, postage 3/-.

SPECIAL OFFER OF EX-GOVT. DRY BATTERIES. 120v. layer type, size 3 x 2½ x 2in., 3/6. 72 v. plus 1½ v. layer type size 6 x 5 x 2 in., 3/6. Heavy duty 1½ v. cells size length 7in. dia. 2½in., 2/6 postage on all batteries 1/6.

BRAND NEW A.M. BLOCK CAPACITORS. By famous makers. 10 mfd. 500 v. wkg. at 60 deg. C. sub chassis mounting, 6/-. 8 mfd. 1,500 v. wkg. at 60 deg. C. 7/6. 8 mfd. 600 v. wkg. at 71 deg. C. 6/6. 4 mfd. 800 v. wkg. at 160 deg. F. 5/6. 4 mfd. 400 v. wkg. at 160 deg. F. 3/9. 2.25 mfd. 2,000 v. wkg. at 160 deg. F. 6/6. 2 mfd. 2,500 v. wkg. at 60 deg. C. 7/6. 0.5 mfd. 2,000 v. wkg. at 140 deg. F. 3/9. 2,000 plus 2,000 mfd. 12 v. wkg. 5/6. Postage on all condensers 1/6.

ALKALINE BATTERIES. Crates of five cells giving 6 v. at 53 A.H. Size of wood crate 15 x 5¾in. x 11½in. **£5/19/6**, plus carr. 7/6. Single cells 2.4 v. 18/20 A.H. Size 4½ x 6 x 3¾in., 15/-, carr. 2/-.

36FT. AERIAL MASTS. R.A.F. Type 50. Complete kit consists of a tubular steel section. Length 4ft. Dia. 2in. Set of pickets. Top plate. Base plate. Guys and all fittings. Supplied new in canvas carrying bags. Ideal for T.V. aerial masts. **£7/10/-**, carr. 7/6. Extra sections 15/- each, carr. 2/-.

NUTS, BOLTS, WASHERS. Special bargain offer. 5/-. Cartons of mixed 2, 4 and 6 B.A. nuts, bolts and washers. Postage 1/-.

CARBON RESISTORS. ½-2 watt. 10/- per 100. Large selection of values. Postage 1/-.

HIGH GRADE SLEEVING. 1½ mil.-5 mil. Mixed bundle. 2/6, postage 1/-.

169/171 Edgware Road, London, W.2. Tel.: PAD 7851

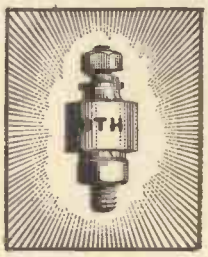
125 Tottenham Court Road, W.1. Tel.: EUS 4982

All orders and enquiries to our Edgware Road branch, please. This is open all day Saturday.

B T-H

GERMANIUM JUNCTION RECTIFIERS

For medium-power application where high efficiency is essential but space limited, these diffused alloy junction-type rectifiers give outstanding performance. They are sturdily constructed, easily mounted and have a working life of many thousands of hours. A new moulded form of construction provides greater stability in service.



Small Size

Overall length including fittings ⅞ in. Diameter ⅛ in. The rectifier is illustrated actual size.

High Efficiency

Excellent forward conduction characteristics which do not deteriorate with age. Voltage drop less than 10% of that across an equivalent thermionic, or dry plate rectifier.

Low Heat Dissipation

At full rating in an ambient temperature of 55°C the dissipation is less than ½ W.

TYPE	Peak Inverse Voltage (V)	FORWARD CURRENT (H/A) at 25°C	at 55°C	at 80°C
GJ3—M	200	550	175	—
GJ5—M	300	550	175	—
GJ6—M	100	750	400	60

BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON COMPANY LTD · RUGBY · ENGLAND

Member of the AEI group of companies

MECHANICAL DESIGNERS AND DRAUGHTSMEN

PHILIPS CROYDON WORKS LIMITED invite applications from Mechanical Designers and Draughtsmen for a number of vacancies now available in the Design Laboratories of their new Radio & Television plant at Croydon, Surrey.

DRAUGHTSMEN — these posts are concerned with manufacturing development for mass production from designers' sketches or models of radio/electronic equipment, and applicants should have experience in light engineering. Production experience would be an advantage.

DESIGNERS — to design electro/mechanical equipment for production in large quantities by flow-line manufacture. Applicants should have a knowledge of press work, automatics, plastic moulding and die casting, and experience of wood cabinet construction and assembly methods would be an added advantage. Candidates should preferably be of HNC standard with workshop experience.

The starting salaries for draughtsmen of the standard required would be £850, per annum, and for designers with the requisite experience and qualifications the minimum starting salary would be £1,000 per annum.

In addition to a progressive salary policy, the Company operates a generous pension and life assurance scheme, together with extended sick-pay and holiday plans.

Applicants who are interested in these opportunities are invited to write to:—

The Personnel Officer,
Philips Croydon Works Limited,
Commerce Way,
Purley Way,
Croydon, Surrey.

quoting reference: No. DD/R.

A.W.F.

Radio Products, Ltd.

SERVE WEST LONDON DEALERS

Wholesale Suppliers to Service Retailers

- **Trade Counter Service** (WES. 5202).
- Send for our comprehensive catalogue. Free and post free, TRADE ONLY.

170-172 WARWICK RD., LONDON,
Between Earls Court & Olympia. W.14.
Office-WEStern 5201 — Counter-WES. 5202
ALSO AT BRADFORD, YORKS.

VACANCIES IN GOVERNMENT SERVICE

A number of vacancies, offering good career prospects, exist for:—

Radio Operators—Male
Cypher Operators—Male and Female

Apply, giving details of education, qualifications, and experience to:—

Personnel Officer,
G.C.H.Q. (FOREIGN OFFICE),
53 Clarence Street,
Cheltenham, Glos.

TECHNICAL ASSISTANT

with O.N.C. or H.N.C. required for work on the development of electronic amplifiers, stabilisers and oscillators in connection with research on new techniques in spectroscopy.

Apply, quoting reference 'L.7', to :—

The Personnel Manager,
Metropolitan-Vickers Electrical Co., Ltd.,
Trafford Park, Manchester 17

RADIO TECHNICIANS IN CIVIL AVIATION

A number of appointments are available for interesting work providing and maintaining aeronautical telecommunications and electronic navigational aids at aerodromes and radio stations in various parts of the United Kingdom.

Applications are invited from men aged 19 or over who have a fundamental knowledge of radio or radar with some practical experience. Training courses are provided to give familiarity with the types of equipment used.

Salary £561 10s. at age 25 rising (subject to a practical test) to £671. The rates are somewhat lower in the Provinces and for those below age 25. Prospects for permanent pensionable posts for those who qualify.

Opportunities for promotion to Telecommunications Technical Officer are good for those who obtain the Ordinary National Certificate in Electrical Engineering or certain City and Guilds Certificates. The maximum salaries of Telecommunications Technical Officers are Grade III £790, Grade II £925, Grade I £1,160.

Apply to the Ministry of Transport and Civil Aviation (ESB1/RT), Berkeley Square House, London, W.1, or to any Employment Exchange (quoting Order No. Westminster 5788).

Murphy Radio

ELECTRONICS DIVISION

Vacancies exist in an expanding laboratory for senior and junior engineers and draughtsmen in the following fields: V.H.F. and U.H.F. transmitters and receivers for use in

NAVIGATIONAL AIDS, MOBILE COMMUNICATION SYSTEMS and PULSE CIRCUITS.

AERIALS.

TELEMETRY EQUIPMENT.

In addition opportunity will arise for applications of TRANSISTORS in these equipments.

Posts are pensionable, Sports Club and other recreational facilities are available. Applications should be addressed to:

Personnel Department (E.29),
Murphy Radio Limited,
Welwyn Garden City, Herts.

APPLIED ELECTRONICS LABORATORIES of THE GENERAL ELECTRIC CO. LTD., Brown's Lane, Allesley, Coventry have the following vacancies in a Group concerned with the Design of Test Equipment for Airborne Radar.

(1) DEVELOPMENT ENGINEER to work on the integration of Automatic Test Equipment with a complex radar. An applicant having a minimum of two years' experience of Radar circuits including data transmission and servo systems would be suitable.

(2) DEVELOPMENT ENGINEER for work on automatic switching circuits and precision signal parameter converters. Experience with electronic and electro-mechanical switching circuits is required. A thorough knowledge of fundamental measurement techniques is essential. Applicant must have had two years' minimum experience of a similar type of work.

(3) JUNIOR DEVELOPMENT ENGINEERS required who must have a sound knowledge of electronics and mechanical principles, with some previous practical experience. Good opportunities exist for advancement.

HOUSE AVAILABLE FOR A SELECTED APPLICANT FOR (1) OR (2).

Reply stating age, qualifications and experience to Personnel Manager (ref. R.G.).

A. V. ROE & CO., LTD

have a number of Vacancies for

QUALIFIED ELECTRONIC ENGINEERS

to work on Britain's most advanced supersonic aircraft.

Applicants should have experience in one of the following :—

ANALOGUE COMPUTER DESIGN
SERVO MECHANISM DESIGN
DIGITAL COMPUTER DESIGN
PULSE CIRCUIT DESIGN

Applicants to have at least Higher National Certificate in Electrical Engineering or equivalent qualification, and at least three years' practical experience on development work.

Apply in writing, quoting Ref. AC/ET/R.174/H *to* :-
Personnel Manager,
A. V. ROE & CO., LIMITED
Greengate, Middleton, Manchester.

THE DE HAVILLAND ENGINE COMPANY LIMITED

has vacancies in its Electro-Dynamics Department, at Stag Lane and Hatfield, and invites applications from Engineers and Physicists who are interested in problems connected with Gas Turbines and Rocket Motors, to fill the following posts:

1 **PHYSICISTS OR ENGINEERS** to be responsible for specialised instrumentation on development engines and aircraft.

2 **ELECTRONIC ENGINEERS** to work under the direction of senior men.

3 **SENIOR MECHANICAL ENGINEERS** with a knowledge of stress analysis and mechanical vibration problems.

4 **JUNIOR MECHANICAL ENGINEERS** interested in experimental stress analysis and vibration problems.

5 **DESIGN DRAUGHTSMAN** for specialised instrument design.

6 **INSTRUMENT MAKER** to be engaged in the manufacture of a variety of tranducers, instruments, etc.

7 **LABORATORY ASSISTANT,** male or female, preferably with G.C.E., to assist in general laboratory experiments and film analysis.

Applicants for the senior posts should be of Degree or H.N.C. standard, but lack of these qualifications need not deter people with experience in these fields.

Salaries will be in accordance with qualifications and experience.

Applications should be made to:—

The Personnel Officer,

The de Havilland Engine Company Limited,

Stag Lane, EDGWARE, Middx.

INSTRUMENTATION RESEARCH

ENGINEER

D. NAPIER & SON LTD., ACTON.

A Senior Appointment is to be made in the near future. Professional Engineers or Physicists with design or development experience in the field of electronic instrumentation circuitry, and capable of initiating and directing such work are invited to apply.

Write in the first instance, giving a full history of experience to date, to Dept. C.P.S., 336/7, Strand, W.C.2, quoting Ref. WW.795B.

R·G·D

Have Vacancies for

HIGHLY QUALIFIED TELEVISION SERVICE ENGINEERS FOR STAFF APPOINTMENTS.

Write to Service Manager,

R.G.D. Service Division, Church Rd., Harold Wood, Essex

THE MULLARD RADIO VALVE CO. LTD.

require a

TECHNICAL ASSISTANT

for investigational work and technical/chemical control of a large Plating Shop. Work is carried out in a modern laboratory on the outskirts of South London. Due to the nature of the work, applicants should possess either G.C.E. advanced level in Chemistry, Inter. B.Sc., or Higher National Certificate.

The commencing salary will be according to age, experience and qualifications.

Applications in writing should be addressed to the Personnel Officer, Mullard Radio Valve Company Limited, New Road, Mitcham Junction, Surrey quoting reference JFG/MR/L.1.

RECORD PLAYERS

GRAM MOTORS
AUTOCHANGERS
CABINETS

Garrard RC.110 3-speed Autochangers. GC2 crystal heads, twin sapphire styli. Maker's cartons. A.C. mains 200/250 volts. £7/19/6, plus 5/6 carr.

Garrard RC.120 3-speed Autochangers, with additional facility of manual control to play single records. GC2 crystal heads. A.C. mains 200/250 volts. £8/19/6, plus 5/6 carr.

Collaro RC54 3-speed Mixer Autochangers, with O or T heads. A.C. mains 200/250 volts. £8/19/6, plus 5/6 carr.

Walnut-veneered Table Record Player Cabinets in drop front style, designed to stand radio on top. Motor board adaptable most non-auto. units, including transcription types. £3/10/-, plus 5/6 carr.

Similar, but Console style, with cupboard below to accommodate 250 records. £3/19/6, plus 5/6 carr.

Thorens Swiss-made Single-speed Autochangers (78 r.p.m.). Cream finish. A beautiful precision job. A.C. mains 200/250 volts. £4/19/6, plus 5/6 carr.

Send stamp for complete bargain lists.

RONALD WILSON & CO.
(DEPT. W.W.), 12 BRIDGE STREET, WORCESTER.

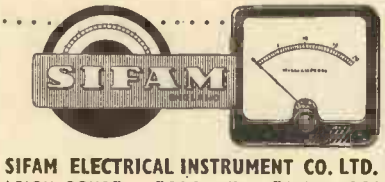
LEO COMPUTERS LTD.
TRAINING TO BE COMPUTER ENGINEERS

Young men with G.C.E. "A" in Physics and Mathematics (or equivalent), without engineering experience, are offered

OPPORTUNITY TO TRAIN AS ELECTRONIC COMPUTER ENGINEERS

This is an excellent opportunity for anyone who has completed National Service (or will do so during 1957) to train from scratch to reach positions of responsibility in this rapidly expanding field. Applicants should write, giving personal and educational details, and an outline of any experience to:

The Personnel Officer, Leo Computers Ltd., Elms House, Brook Green, London, W.6.



SIFAM ELECTRICAL INSTRUMENT CO. LTD.
LEIGH COURT - TORQUAY - Telephone 4547/8

FOR PROMPT DELIVERY

WAFER SWITCH ASSEMBLIES, CUSTOM BUILT

Banks	PAXOLIN	CERAMIC
	s. d.	s. d.
1	7 0	11 3
2	10 3	22 7
3	13 6	33 4
4	16 2	45 2
5	18 10	56 2
6	21 6	67 8
7	23 8	—
8	26 11	—

When A.B. 11 and 12 way Wafers are required, please add 1/- per bank to above prices.
SPECIALS AT time & material plus 50%.

● N.S.F. TYPE "G" SWITCHES.

1 Bank	£1 4 0	Control Plate etc., each 15/-
2 Banks	£1 13 0	
3 Banks	£2 2 0	
4 Banks	£2 11 0	Wafers, each 9/-
5 Banks	£3 0 0	
6 Banks	£3 9 0	

Quotations gladly given for small as well as large quantities, also for special assemblies.

TELE-RADIO (1943) LTD.
189, EDGWARE ROAD, LONDON, W.2.
Paddington 4455/6.

WAR DEPARTMENT

Vacancies exist for eight temporary civilian instructors Grade III to teach Radio Technicians, Line Technicians and Telegraph Technicians in the theory, installation, repair and maintenance of modern Services telecommunication equipment. Applicants should have served an acceptable apprenticeship, be fully experienced in the trade and capable of teaching subjects included in one or more of these trades.

The possession of Ordinary National Certificate, or equivalent qualification in Telecommunications is desirable.

Appointments will be made after testing and interview by a Board of Officers and will be subject to six months' trial.

Salary:

Grade III £716 (at age 28) rising by annual increases subject to satisfactory service to £833, for a 5½ day week of 44 hours.

Apply in writing to:

Officer Commanding,
1st Training Regiment,
Royal Signals,
Catterick Camp, Yorkshire.

Closing date for receipt of applications is 9th March, 1957.

ENGLISH ELECTRIC COMPANY LIMITED
STEVENAGE HERTS

have immediate vacancies for

TELEMETRY ENGINEERS

in the newly formed Test Department of the Company's Guided Weapons Division.

Applications are invited from engineers who are experienced in Instrumentation Planning and in the preparation and testing of Missile Telemetry Systems.

Housing assistance available.

Apply to Dept. C.P.S. 336/7 Strand, W.C.2., quoting Ref. WW1312A.

ENGINEERS

(Electrical and Mechanical)

PHYSICISTS

Required for work on development, manufacture and circuit application of special radio valves, including microwave devices.

Minimum Qualifications, H.N.C. or DEGREE.

Experience is desirable but not essential.

Initial training at The Research Laboratories of The General Electric Company will be available for selected candidates.

These are progressive positions with good opportunities for advancement.

Apply quoting TC/1 to:—

M.O. Valve Co.,
Osram Works,
Brook Green,
Hammersmith, W.6.

MANUFACTURERS OF VALVES FOR G.E.C.

TESTERS REQUIRED

for

RADAR & ELECTRONIC WORK

Holding of Ordinary or Higher National Certificate an advantage, but men with suitable Service or Civilian experience will be considered. Opportunities for advancement available for progressive candidates.

Good rates of pay, conditions, canteen facilities, etc.

Apply in person or in writing to:—

Employment Department.
Metropolitan-Vickers Electrical Co., Ltd.,
Trafford Park, Manchester 17

N.B.: For the convenience of applicants the Employment Department is open for interviews as follows:—

Monday and Friday 8.30 a.m. to 4 p.m. Tuesday, Wednesday and Thursday 8.30 a.m. to 6.30 p.m., and Saturday 8.30 a.m. to 11.30 a.m.

MULLARD RESEARCH LABORATORIES

require

Engineers, Physicists
and
Mathematicians.

The Telecommunications Division of Mullard Research Laboratories has some vacancies in expanding research teams engaged in radar, microwave, telecommunications and particle accelerator programmes. Engineers, physicists and mathematicians who enjoy working in an atmosphere of enthusiasm and who wish to extend their interests and experience to new fields are invited to apply. Recent research or advanced development experience will be an advantage. In general, university graduates will be appointed to fill these vacancies, but applications from holders of the Higher National Diploma or Certificate will be sympathetically considered.

Excellent conditions of employment, including Superannuation and Life Assurance Scheme. Apply Mr. G. A. Taylor, Personnel Officer, Mullard Research Laboratories, Cross Oak Lane, Salfords, Redhill, Surrey, quoting reference RNG.

THE MULLARD RADIO VALVE CO. LTD.

require an

ASSISTANT ANALYST

with Inter. B.Sc., or equivalent, for work of a non-routine and varied nature. Applicants should not be aged more than 35.

The work is carried out in a modern Laboratory on the outskirts of South London.

The commencing salary would be according to age, experience and qualifications. The Company's salary policy can be considered to be progressive, and there is a Pension Scheme and long service holiday plan.

Applications in writing should be addressed to the Personnel Officer, The Mullard Radio Valve Company Limited, New Road, Mitcham Junction, Surrey.

ENGLISH ELECTRIC VALVE CO. LTD.

CHELMSFORD

Have opening for Electrical Engineer, Physicist or Chemist able to speak and to write fluently in Spanish; a similar knowledge of Portuguese is also desirable.

There is a non-contributory superannuation scheme and the Company will assist successful candidates to obtain suitable accommodation.

Please write to Dept. C.P.S., 336/7, Strand, W.C.2. quoting Ref. WW 1516A.

TEST ENGINEERS

required for interesting work in connection with Radar, Television Film Projectors, Camera Channels, Microwave Links and similar electronic equipment. Applicants must have sound theoretical knowledge of electronics backed by practical experience In H.M. Forces or Industry. Staff positions and Superannuation Scheme. Single accommodation available. Apply giving full details to the

Personnel Dept. (C.E./21), E.M.I. Ltd., Hayes, Middx.

THE MULLARD RADIO VALVE CO. LTD.

require a

LABORATORY ASSISTANT

with Inter. B.Sc. or Higher National Certificate in Chemistry for investigational work on problems associated with materials used in manufacturing and development in the Electronic Industry.

The work is carried out in a modern Laboratory on the outskirts of South London.

The commencing salary would be according to age, experience and qualifications. The Company's salary policy can be considered to be progressive, and there is a Pension Scheme and long service holiday plan.

Applications in writing should be addressed to the Personnel Officer, The Mullard Radio Valve Company Limited, New Road, Mitcham Junction, Surrey, quoting reference JFG/MRL.

Z & I AERO SERVICES LTD.,

Fully Serviced and Guaranteed Test Equipment

MARCONI TF144G "STANDARD" SIGNAL GENERATOR, range 85 kc/s to 25 mc/s; output 1μV to 1 volt; completely overhauled, with mains and output leads £85 0 0

8in. SCALE EDGEWISE MOVING COIL INSTRUMENTS, originally designed for remote pressure indication; calibrated 20 to 800 or 10 to 400 mm. Hg. Sensitivity of the order of 30 microamps for F.S.D.... £7 15 0

MARCONI TF390G SIGNAL GENERATOR, range 16 to 150 mc/s, indirect calibration; output 1μV to 100 mV; 400 c/s internal modulation; complete with output lead and attenuator pad £25 0 0

MARCONI TF517F SIGNAL GENERATOR, range 18 to 58 mc/s (indirect cal.) and 150 to 300 mc/s (direct cal.); output 200 mV max; 1,000 c/s Internal modulation sinewave and squarewave; complete with two concentric leads (mod. and output) and 26db att. pad £35 0 0

EVERSHED TWIN PEN VOLTAGE RECORDER, range 160-250V A.C., clockwork movement £75 0 0

INSULATION TESTERS

EVERSHED WEE MEGGERS, 500 V. £12 10 0

EVERSHED WEE MEGGERS, 250 V. £11 10 0

RECORD 500 V. INSULATION TESTER £10 0 0

All the above instruments are complete with leather cases.

EVERSHED 500 V. MEGGERS, 40 MO £22 10 0

EVERSHED 1,000 V. MEGGERS, 100 MO £27 10 0

EVERSHED 1,000 V. BRIDGE MEGGER, 200 megohms £55 0 0

TS-127 LAVOIE (model 105SM) U.H.F. FREQUENCY METER, range 375 to 725 mc/s.
PRICE, second-hand, fully overhauled £25 0 0
PRICE, brand new, with spare valves and accessories £32 10 0

MARCONI CR-150 COMMUNICATION RECEIVERS, range 2 to 60mc/s, double superhet
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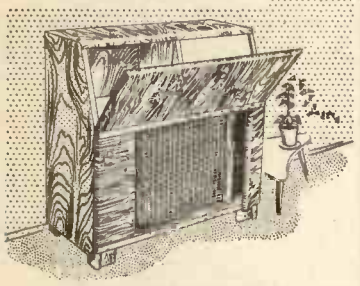

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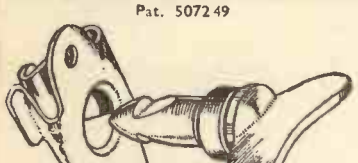

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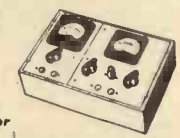

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COMMUNICATIONS Engineer, practical man for development work, previous experience electronic mechanical devices, including magnetic recording; C. & G. in telecomms. or similar qualifications desirable; well-established company with pension scheme.—Full details of previous career and salary required to S. E. Opperman, Ltd., Boreham Wood, Herts. [6765

THE Research Laboratories of the General Electric Co., Ltd., North Wembley, Middlesex, have several vacancies for technical assistants; applications are invited from young men who are free from National Service commitments.—Pease write to the Staff Manager (Ref. RLB '116), giving details of experience, qualifications and age. [6744

MURPHY RADIO, Ltd., have vacancies in the radio and television laboratories for senior and junior engineers; these posts offer excellent prospects of advancement.—Applications, giving full details of experience and qualifications, should be addressed initially to Personnel Department (R6), Murphy Radio, Ltd., Welwyn Garden City, Herts. [6568

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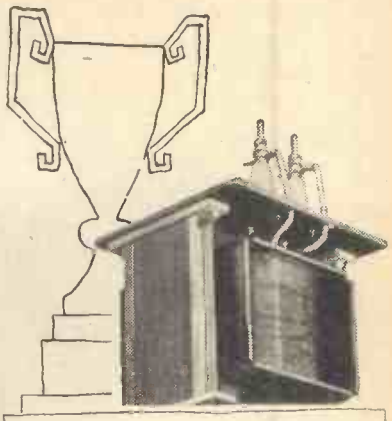

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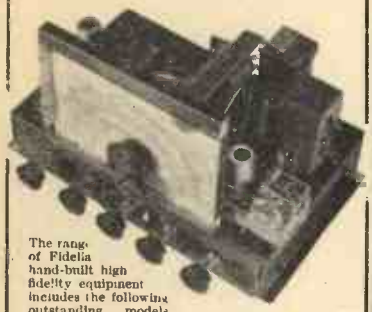

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ELECTRONICS technician.—May & Baker, Ltd., Dagenham, Essex, require an electronics technician (aged 25-30) to construct and maintain electronic apparatus for research in the laboratories of their Biological Research Group, workshop experience is expected, ability to design circuits would be advantageous but is not essential, the position requires a keen practical interest in electronics and personal initiative, since the work is varied and not routine; salary according to experience and qualifications.—Apply initially in writing, quoting reference No. 17, to the Personnel Officer. [6742

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SELENIUM Rectifiers.—Senior Executive required by expanding company in North Midlands area to direct research and production of selenium Rectifiers; a knowledge of Germanium and Silicon Rectification would be useful; this is an important appointment with a progressive organisation and offers exceptional opportunities to the successful applicant with suitable experience, initiative and energy.—Applications marked "Personal" to Managing Director, Box 5146, quoting details of education and training, qualifications, career, age and salary required. All applications will be treated in strictest confidence. [6559

ELECTRONICS engineer.—A vacancy exists for a qualified electronics engineer to take charge of a small Development Laboratory in the West London Area; the work is in connection with the design and manufacture of electronics equipment for use in the design and testing of supersonic aircraft; experience in any of the following would be an advantage: analogue computers, digital computers, servo-mechanisms and low power pulse circuits; good salary and excellent prospects for an engineer with initiative and enterprise.—Apply quoting Reference No. AC/CHERT/R. 195W to: Personnel Manager, A. V. Roe & Co., Ltd., Greengate, Middleton, Manchester. [6743

AIRCRAFT electrical engineers, senior & junior are required for development of aircraft relays and switch gear, the work is of great interest involving electromechanical principles, experimental and manufacturing techniques; initiative and ability to handle all stages of development are essential for senior posts; experience of similar work is not essential for the junior posts although applicants should have completed National Service; excellent prospects and good salaries for the right people; contributory pension scheme.—Apply in writing quoting ref. No. B 7055 to Employment Department, Thorn Electrical Industries, Ltd., Great Cambridge Rd., Enfield. [6778

THE Decca Navigator Company, Ltd., Technical Publications Section.—Require a radio engineer with an interest in technical writing and/or training, to undertake the preparation of handbooks and to take charge of short training courses on specialised radio-navigational equipment, ex officers or senior N.C.O.s with suitable technical qualifications and experience would be considered; this new vacancy, resulting from the rapid and continuous expansion of the Decca Navigator System, offers excellent prospects in a field of unusual technical interest.—Apply in writing, giving full details to Personnel Officer, Decca Navigator Co., Ltd., Shannon Corner, New Malden, Surrey. [6726

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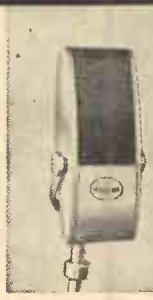

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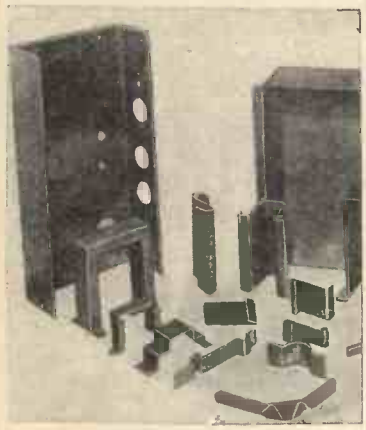

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PENSION scheme.—Apply in writing giving full particulars to Personnel Officer, Prefect Works, Purley Way, Croydon, Surrey. [6724

ELECTRONIC Engineers who wish to specialise in the servicing of Hollerith Electronic Computers (HEC) are invited to apply for employment with The British Tabulating Machine Co., Ltd. The applicants should have had varied experience either in industry or in the services (i.e., P.O. Radio Electrician, R.N. and etc.) on radar, television or similar complex electronic equipment. Preference will be given to qualified men holding H.N.C. Electronics, H.N.C. Electrical or similar City and Guilds Radio and Telecommunication; although this will be waived for ex-H.M. Forces candidates who have received appropriate service training, but a high standard of mathematics is desirable. Good salaries are paid during training and subsequent progress will be according to ability. The staff appointment is with a non-contributory sick pay scheme, a contributory pension scheme and etc. Suitable qualified applicants aged 25/35 years of age should apply in strictest confidence to the Staff Manager, Field Engineering, The British Tabulating Machine Co., Ltd., 17, Park Lane, W.1. [6732

TECHNICAL Assistants Grade I required by Kumasi College of Technology, Gold Coast. Department of Electrical Engineering (M2C/41848/WF) and Radio Research Laboratory (Ionosphere Research) (M2C/42178/WF). Appointment for two tours normally of ten months each in first instance, either (a) on agreement with prospect of pensionable employment salary scale (including 5% non-pensionable addition), £871, rising to £1,060 a year, or (b) on contract with above salary scale plus 10% contract addition and gratuity at rate of £150 a year. Commencing salary according to experience. Outfit allowance up to £60. Furnished quarters available for officer and family. Free passages. Leave on full salary normally granted annually. Preservation of superannuation rights under F.S.S.U. Scheme might be arranged. Candidates must possess H.N.C. or equivalent and have experience in research laboratories of manufacturer of telecommunications equipment or of an operating organization.—Write to the Crown Agents, 4, Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote the reference number shown against the post applied for. [6875

I.B.M. UNITED KINGDOM LIMITED requires a number of electrical and/or electronic engineers for training on electric and electronic data processing machines (punched card accounting machines and digital computers). Men aged 21-30 who have reached H.N.C. standard or equivalent and who are desirous of a career in office automation are invited to apply. Selected men will first receive a period of basic practical and theoretical training at the Company's training centre in London, followed by approximately four months' training with senior engineers on installations in customers' offices and will then be appointed to specific installations, every consideration being given to preferred locations. Subsequent training, mainly on computers, arranged as necessary. Starting salary is £600 p.a., which is increased by £50 at the end of the four months' basic course. Subsequent increases based on merit will reach £1,000 in 4-8 years, and there are excellent opportunities for promotion. Free insurance comes into operation after one year's service. Applications for next course (March) as soon as possible in own handwriting, please, to the Personnel Manager, 100, Wigmore St., London, W.1, quoting Ref. C.E.22. [6715

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TCC

"SUPERLYTICS"

HIGH QUALITY ELECTROLYTICS

These small, high capacity electrolytics have the electrical advantages of paper dielectric, due to the use of carefully selected materials and special processing.

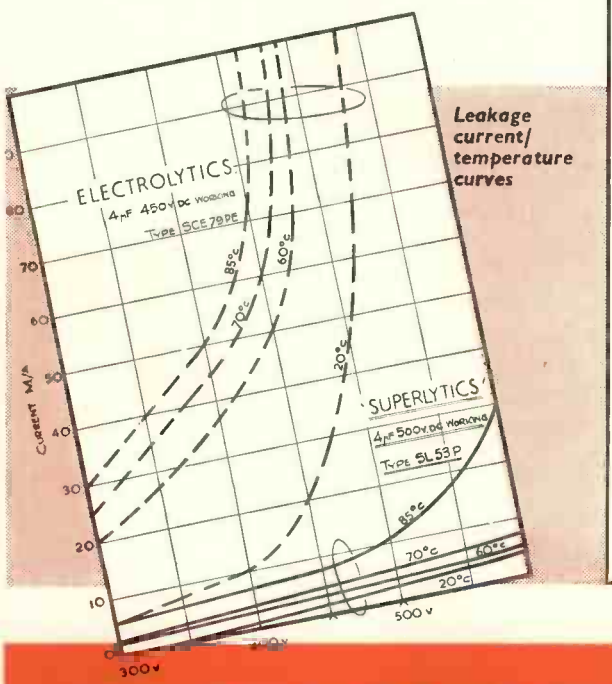
Their inherently low-leakage current makes them suitable for very low-frequency amplifiers where high I.R. is essential for the lower registers. Telephone equipment and circuitry working unattended over long periods benefit from the long life factor of "Superlytics".

The graph shows the extremely low leakage in comparison with that of the standard electrolytic. I.R. is maintained even after six months idling and 100 megohms/µF is attained after only three minutes of applied working voltage, rising rapidly to 10,000 megohms/µF if left in circuit.

Capacity Tolerance: —20% +50%.

Working Temperature is —20°C. to 85°C. without voltage derating; if raised to 100°C. the life may be only a thousand hours or so.

Polarity is clearly indicated by colour of end seals.



Leakage current/temperature curves

Capacity in µF.	Wkg. Volts D.C.	Dimns. in Ins. L.	Dimns. in Ins. D.	T.C.C. Type No.
12	25	1 5/8	0·34	SL78C
25	25	1 3/4	0·44	SL73C
50	25	1 15/16	0·6	SL74C
12	50	1 3/4	0·44	SL73D
25	50	1 15/16	0·6	SL74D
40	50	1 15/16	0·6	SL74D
1	100	1 3/8	0·34	SL75E
2	100	1 3/8	0·375	SL70E
4	100	1 5/8	0·375	SL77E
8	100	1 13/16	0·5	SL79E
16	100	1 15/16	0·6	SL74E
0·5	150	1 1/8	0·25	SL72F
1	150	1 3/8	0·34	SL75F
2	150	1 5/8	0·375	SL77F
4	150	1 13/16	0·5	SL79F
8	150	1 15/16	0·6	SL74F
0·5	250	1 3/8	0·34	SL75H
1	250	1 5/8	0·375	SL77H
2	250	1 3/4	0·44	SL73H
4	250	1 15/16	0·6	SL74H
8	250	2 1/4	0·75	SL11H
16	250	1 3/4	1·00	SL24H
32	250	2 3/4	1·00	SL26H
4	500	4 1/2	1·00	SL53P
8	500	4 1/2	1·375	SL37P

THE TELEGRAPH CONDENSER CO. LTD

RADIO DIVISION: NORTH ACTON · LONDON · W.3 · *Tel:* Acorn 0061 (13 lines)

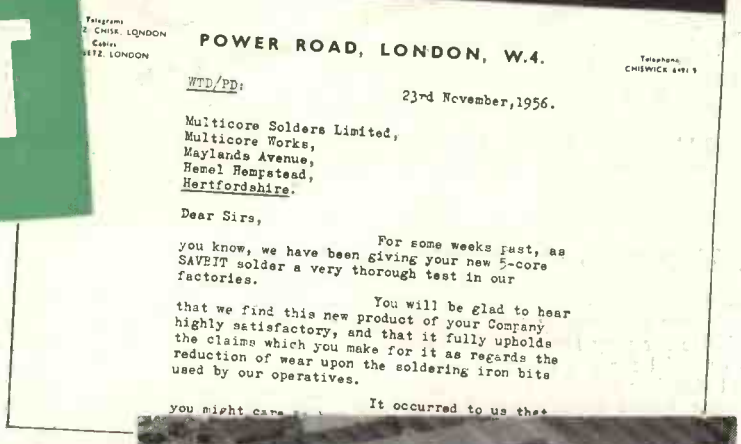
SPECIALISTS IN CONDENSERS SINCE 1906

Ersin Multicore

SAVBIT
TYPE 1 ALLOY

stands up to the severe tests of

BUSH RADIO LTD



POWER ROAD, LONDON, W.4.

WTD/PD: 23rd November, 1956.

Multicore Solders Limited,
Multicore Works,
Maylands Avenue,
Hemel Hempstead,
Hertfordshire.

Dear Sirs,

For some weeks past, as you know, we have been giving your new 5-core SAVBIT solder a very thorough test in our factories.

You will be glad to hear that we find this new product of your Company highly satisfactory, and that it fully upholds the claims which you make for it as regards the reduction of wear upon the soldering iron bits used by our operatives.

It occurred to us that

W. T. DEUCHRASS, WORKS DIRECTOR, states that Bush Radio Ltd. have tested Ersin Multicore Savbit Type 1 alloy on the production line and found it to be highly successful.

Bush Radio Ltd. are now using substantial quantities of this 5-core solder which reduces the amount of copper absorbed from the solder bit, extending the useful life of bits by up to 10 times.

Savbit costs less than 60/40 alloy. Full technical details and advice will be gladly supplied by the Multicore Technical Service Department on request.

British Patent Nos. 704,763. 721,881.

SAVBIT PACKS

7 LB. REEL

Savbit Type 1 Alloy which contains 5 cores of non-corrosive Ersin Flux is supplied in 3 gauges on 7 lb. reels for factory use. Ersin Multicore 5-core Solder is also available on 7 lb. reels, in 6 standard tin/lead alloys and 9 gauges. Prices on application.

1 LB. REEL

Approximately 170 ft. of 18 s.w.g. Ersin Multicore Savbit Type 1 Alloy is wound on the 1 lb. reel. This is a convenient quantity for factories where each operative uses a comparatively small quantity of solder at a time. 15/- each (subject).

SIZE 1 CARTON

5/- each (subject)

Savbit Type 1 Alloy is also available in cartons containing 53′ of 18 s.w.g. Ersin Multicore Solder is also available in 4 other specifications.

Catalogue Ref. No.	Alloy Tin	Alloy Lead	S.W.G.	App. l'gth per carton
C 16014	60	40	14	19 feet
C 16018	60	40	18	51 feet
C 14013	40	60	13	17 feet
C 14016	40	60	16	36 feet

MULTICORE SOLDERS LIMITED, MULTICORE WORKS, HEMEL HEMPSTEAD, HERTS. (BOXMOOR 3636)